HONDURAS SORGHUM.

SORGHUM

ITS CULTURE AND MANUFACTURE

ECONOMICALLY CONSIDERED

AS A SOURCE OF

SUGAR, SYRUP, AND FODDER

BY

PETER COLLIER, Ph. D

Late Chemist of the United States Department of Agriculture, Washington, D. C.

CINCINNATI

ROBERT CLARKE & CO

1884

CONTENTS.

CHAPTER I.

CHAPTER II.

CHAPTER III.

CHAPTER IV.

CHAPTER V.

CHAPTER VI.

CHAPTER VII.

CHAPTER VIII.

CHAPTER IX.

CHAPTER X.

CHAPTER XI.

CHAPTER XII.

CHAPTER XIII.

CHAPTER XIV.

CHAPTER XV.

CHAPTER XVI.

APPENDIX.

PREFACE.

It is the purpose of this work to present, in a systematic manner, all the most important facts relating to the economical production of sugar, syrup, and fodder from sorghum. The attempt has been made to separate that which is demonstrable from the vast accumulation of statements, true and fanciful, which have been given publicity since the first introduction of sorghum into the United States.

While chemist of the United States Department of Agriculture, in the years 1878 to 1882 inclusive, the writer enjoyed exceptional advantages for the scientific study of different varieties of sorghum during all stages of development. The large amount of analytical work then accomplished, together with numerous laboratory experiments in various directions, have served to demonstrate many important questions previously unsolved or in dispute, and have led the way for larger practical experiments. All the material thus accumulated has been condensed and classified in this volume, and it is hoped that it has been so presented as to render it serviceable and comprehensible alike to farmers, sugar makers, and chemists.

In like manner, the actual working results of numerous practical experiments in the production of sugar from sorghum have been given in detail, together with illustrations and descriptions of all necessary apparatus. Credit has been given to other investigators, and, so far as is known to the author, all important results obtained by others have been included in this work.

There is no longer any reason to doubt that, when mature,

most varieties of sorghum contain an amount of crystallizable sugar sufficient to yield a very substantial profit to those who employ proper manufacturing methods. As in all new and great industries, there are still many unsolved questions relating to the perfection and cheapening of working processes. It must not be expected that all beginners will be successful, for the neglect of necessary precautions is very likely to be followed by failure; but, with proper conditions and attention to the rules for practice here laid down, it is believed that the successes will greatly outnumber the failures.

There was a time in the earlier years of the present century, when sugar seems to have been considered a luxury, chiefly to be enjoyed by the wealthy, and when the average annual supply fell short of ten pounds per capita. Now, sugar may safely be classed among the staple articles of food which we term necessities, and the average consumption is about forty pounds per year for each person in the United States.

The sum annually paid to foreign nations for this great amount of sugar exceeds one hundred million dollars, and the first cost is further augmented by the tax of nearly fifty million dollars which is levied by our government.

In the matter of supplying our own demands, this country has never been able to make much headway, our present capacity being equal only to about one-eighth of the total consumption. Because the tropical sugar-cane can only be successfully grown in a very restricted area, and also owing to the fact that early frosts endanger the crop and compel sugar makers, in our southern states, to work up the canes while immature and containing less than the maximum amount of sugar, the production of all our sugar from the cane, within our present boundaries, can not be considered probable.

In sorghum, we have a plant botanically related to the tropical sugar-cane, and resembling it in capacity for the production of sugar, while it possesses the very important advantage that it is much more hardy, and, like Indian corn, to which it is also related, may be easily and successfully cultivated in nearly every state of the Union.

It is the author's belief, based upon the actual experience of four seasons' constant experimentation, that the sorghum plant is destined, sooner or later, to furnish not only all the sugar needed in this country, but also a very considerable proportion of that required by foreign nations. That these are not the unwarranted opinions of an enthusiast, will appear from the report, upon this subject, by the special committee of the National Academy of Sciences, which is here included.

It is the fortune of most investigators, who are so daring as to show, in advance, the great possibilities of some new industry, to meet ridicule, and even hostility from those who fail to comprehend the full import of the discoveries which have been announced. The writer has not been spared this infliction; but, as an offset, he has already had the satisfaction of witnessing the actual production of good sugar from sorghum on a large scale, and at moderate cost.

If, in part, as a result of his labors, the sorghum sugar industry shall ultimately be established in this country upon a sound basis, any personal inconvenience will be amply compensated by the great satisfaction attending the success of an enterprise of such consequence. It is hoped that this book may be of service to many who shall undertake the cultivation of sorghum and the manufacture of sugar, and that it may also serve to extend an industry both promising and important, as a new source of national wealth.

WASHINGTON, D. C., *March*, 1884.

SORGHUM;

ITS CULTURE AND MANUFACTURE.

CHAPTER I.

(*a.*) Conflicting opinions on essential points before the investigations at the Department of Agriculture.
(*b.*) History of the development of the Beet Sugar Industry in Europe.
(*c.*) Necessity for further research.
(*d.*) Future prospects of the Sorghum Sugar Industry.

PRELIMINARY.

In 1877, when the author was invited to take charge of the Chemical Division of the Department of Agriculture, at Washington, the Commissioner of Agriculture, General Wm. G. Le Duc, directed him to undertake the investigation of sorghum and maize as sugar producing plants, since the results, recently secured in Minnesota, from a variety of sorghum known as the "Early Amber," had again aroused the public interest, which for some years had been dormant, as to the possibility of producing our own supply of sugar. The investigation was begun during the season of 1878, and with results so satisfactory and surprising, that it was the determination of the Department to prosecute them to the end. From each of four varieties of sorghum grown upon the grounds of the Department, there was made a large quantity of excellent sugar by processes practically identical with those used upon the sugar plantations of Cuba and Louisiana; and the quantity of sugar obtained from the crop, was fairly comparable with that obtained from the sugar-cane.

These investigations were continued by the author during the years 1879, 1880, 1881, and 1882, although without the facilities, during the last two years, to make them fully successful. The result has been, that the sorghum sugar industry, during the past three or four years, has been developed to a degree that, while it has hardly reached the proportions which its ardent advocates have anticipated, has at least confounded and silenced those who have from the first predicted failure.

It is hardly surprising, that the results obtained at the Department

of Agriculture, in the investigations of sorghum and maize, and the predictions based upon these results, should have met with much incredulity; since it is well known that, during the past thirty years, these plants have been the subject of repeated, though incomplete, investigations by many whose official position and professional standing were such as to entitle them to the confidence of the community.

Naturally, results which have often been at variance with their own, have met with a revision of unusual severity by other investigators; but, since the methods by which these results were obtained were the best known, a cordial acceptance of them has been given, so far as I know, without exception, among scientific men.

With another class the case has been quite different—those who, Bourbon-like, neither learn nor forget. From them there has been, from first to last, only ungenerous criticism or actual hinderance; which has been so unjustifiable and so marked as to prompt one of our leading papers editorially to declare, of one of this class, that "his entire course in the matter has been unreasonable, obstructive, and, apparently, malevolent." One of the most effective and frequent methods of this class in belittleing the work at the Department of Agriculture, and opposing the acceptance of the important results obtained by means of these investigations, has been to assert that, "after all, there was nothing new in all this, for it had all been done twenty years ago." Such and similar statements have been urged to cast doubt upon this whole matter; to destroy public confidence in the truth of the results obtained; to prevent their practical acceptance by the people: and thus to prevent the realization of those practical results which have been predicted and based upon the general acceptance of these results. That such predictions have not been fulfilled, is the exact measure of responsibility resting upon those who have thus, from whatever motive, misled the people.

It is needless here to enter into any discussion as to whether all these facts were known and recognized twenty years ago—as to whether or not, in all this work done at the Department of Agriculture, from 1878 to 1882 inclusive, there was any thing new. It is simply a matter of fact and of record; and it may be best, before proceeding further, to learn what was the state of our knowledge previous to these investigations.

CONFLICTING OPINIONS ON ESSENTIAL POINTS.

The following citations are by no means an exhaustive summary; but are, probably, sufficient to show the wide differences of opinion on

nearly every important point of the subject entertained by the several authorities quoted.

A few only of the more important points of this inquiry have been selected as illustrations, and the conclusions reached are grouped under each head and chronologically arranged.

Of the kind of Sugar present in the juice of Sorghum.

a. In a paper by D. Jay Brown (Annual Report, Department of Agriculture, 1856, p. 310), he says:

Mr. Hervey, of France, contends that there is no uncrystallizable sugar pre-existing in the cane (sorghum), and that the formation of glucose (grape sugar), or molasses, is only owing to the action of the salts contained in the liquid during the manufacturing process.

b. Dr. C. T. Jackson (Annual Report, Department of Agriculture 1857, p. 187), says:

There is no doubt that this plant (sorghum), when unripe, contains only grape sugar.

c. Dr. J. Lawrence Smith, in a paper detailing the results of his investigations of sorghum (Annual Report, Department of Agriculture 1857, p. 192), says:

This result settles the question *that the great bulk of the sugar contained in the sorgho is crystallizable, or cane sugar proper.*

And again, giving his final conclusions, he says:

1. The sorgho contains about 10 per cent of crystallizable sugar.
2. The sugar can be obtained by processes analogous to those employed for extracting sugar from other plants.

In an article entitled "Contributions to the knowledge of the nature of the Chinese sugar-cane" (Transactions New York State Agricultural Society, 1861, p. 785), by Dr. C. A. Goessmann, he says, p. 789:

The facts so far obtained prove, that, besides cane sugar, no other kind of sugar exists in the juice of the ripe and sound sorghum-cane.

Again, in describing the general properties of the sorghum-cane juice, he says, p. 798:

I have already mentioned, that the results which I obtained entitled me to believe that cane sugar is the only kind of sugar that exists in that juice.

And on page 808, he says, of results in extracting sugar from sorghum:

These results are very encouraging, as they show that more than half the sugar, or 5 per cent out of 9 to 9½ per cent, in the juice can be separated. When Achard established the first beet sugar manufactory in Silesia, he was able to separate only from 3 to 4 per cent of sugar, although 10½ per cent was present; and the French manufactories were quite contented when they succeeded in extracting from 4 to 5 per cent of sugar. The history of the de-

velopment of the manufacture of beet sugar may be studied with great advantage by those interested in the sorghum.

d. Dr. Thomas Antisell, chemist, Department of Agriculture (Annual Report, Department of Agriculture, 1866, p. 48), says:

The sorghum, while it contains some cane sugar in its early juice, loses it as it advances in life; and, in all cases, by the usual methods of defecation and classification, its existing sugar is almost wholly converted into uncrystallizable sugar.

Again, Dr. Antisell says (Annual Report, Department of Agriculture, 1867, p. 33):

The attempt to separate and crystallize the cane sugar of sorghum on a large scale, has been wholly unsuccessful, and, as a sacchariferous plant, it is only valuable for molasses.

e. Dr. C. A. Goessmann, chemist of Massachusetts State Agricultural College, under date January 25th, 1881, says:

The sorghum juice furnishes, when properly treated, a good syrup; yet it is of little importance for the production of sugar.

f. President Stockbridge, of the Massachusetts Agricultural College, in his Annual Report, December, 1881, p. 19, says:

The experiments with sorghum, as a sugar producing plant, forever settled the fact that no known variety of it can be profitably employed for the purpose, unless chemical science can discover a law by which glucose can be changed for cane sugar.

The Best varieties of Sorghum for the production of Sugar.

In the Sorgho Journal for February, 1869, p. 9, the editor, William Clough, says:

The Oomseeana is altogether the best, Neeazana is next, for making sugar. It is not worth while to try to make sugar of any other variety which we now possess.

Again, p. 26, he says:

It [the Oomseeana] is the only cane upon which the operation for sugar can be conducted with any certainty.

Again, he says:

Spend no time in attempting to make sugar from any but the Oomseeana or Neeazana varieties.

Again, same page, he says:

Its syrup does not tend to granulate.

Time for harvesting and working the Sorghum, and when the maximum of Sugar is present in the juice.

a. In the Annual Report, Department of Agriculture, 1854, p. 222, M. Vilmorin, of Paris, is quoted as concluding that

The proportion of sugar in the stalks continued to increase until the seeds were in the milky state. * * * The ripeness of the seeds does not appear much to lessen the production of sugar, at least in the climate near Paris; but in other countries, where it matures when the weather is still warm, the effect may be different.

b. J. H. Hammond, Silverton, S. C. (Annual Report, Department of Agriculture, 1855, p. 282), found, by his experiment (he records one only) with sorghum, taken before the seed was in the milk, when it was in the milk, and when it was mature, that

The youngest canes had rather the most, and the oldest rather the least, saccharine matter. * * * Beginning to cut the cane as soon as the head is fully developed, it may be secured for a month before it will all ripen: how long after that, I do not know.

c. Dr. C. T. Jackson (Annual Report, Department of Agriculture, 1856, p. 307) found that

The juice from stalks with quite ripe seeds was by far the sweetest, while the green ones, which were just in flower, contained but very little saccharine matter.

Upon page 312, Louis Vilmorin is quoted as saying:

The crystallization of the sugar of the sorgho, it seems, should be easily obtained in all cases where the cane can be sufficiently ripened; and, as the proportion of the sugar is an unfailing index of ripeness, it follows, that we could always be sure of obtaining a good crystallization of juices, the density of which exceeds 1.075, while weaker ones could not yield satisfactory results after concentration.

Again, he says, same page:

This difficulty [of purging, through presence of gum] only presents itself in the employment of unripe canes; for, as soon as the juices attain the density of 1.080 and more, they contain little else than crystallizable sugar, and their treatment presents no difficulty.

d. Dr. C. T. Jackson, in his report (Annual Report, Department of Agriculture, 1857, p. 187), says:

A ripe plant yielded a juice of 1.062 sp. gr., which yielded 16.6 per cent of thick syrup, which crystallized almost wholly into cane sugar, the whole mass becoming solid with crystals.

And he concludes:

From these researches, I am fully satisfied that both the Chinese and the African varieties of sorghum will produce sugar of the cane type, perfectly and abundantly, whenever the canes will ripen their seeds.

Again, he says:

The unripe canes can be employed for making molasses and alcohol, but, as before stated, will not yield true cane sugar.

e. The committee of the United States Agricultural Society, ap-

pointed to investigate the subject of sorghum, in their report (Annual Report, Department of Agriculture, 1857), say:

Where the plant was well matured, the juice yielded from 13 to 16 per cent of dry saccharine matter, from 9 to 11 per cent of which was well-defined crystallized cane sugar. * * * A palatable bread was made from the flour ground from the seeds. * * * Paper of various qualities has been manufactured from the fibrous parts of the stalks.

f. J. N. Smith, of Quincy, Ill. (Annual Report, Department of Agriculture, 1862, p. 134), says:

The syrup [from sorghum] will not make sugar if the cane is cut before the seed is in the dough. * * * The crop should be allowed to stand in the field as long as possible, without being in danger of frost.

g. L. Bollman, Bloomington, Iowa, upon page 147, *loc. cit.*, says:

To me it is obvious, that the chief requisite for sugar making from the sorghum canes is their *perfect maturity*, and such maturity is dependent on correct cultivation and late cutting.

h. J. Stanton Gould, in a report on "Sorghum Culture," made to the New York State Agricultural Society, 1863 (Transactions New York State Agricultural Society, p. 752), says:

The seed of the cane [sorghum] continues in the dough for about a week. It is the general impression that the cane should be cut during this period, as it is then supposed to have the greatest amount of saccharine matter; at least, this is thought to be true of all the varieties except the white imphee, which is usually cut *just as it is going out of the milk, or just entering the dough.*

i. William Clough, editor Sorgho Journal, Cincinnati, Ohio (Annual Report, Department of Agriculture, 1864, p. 59), says:

The precise period most appropriate for harvesting the cane, is when the saccharine properties are fully developed, and before any supplementary action sets in. This will be found to be at the time when the seed at the middle of the panicle is just beginning to harden, or to pass from the fluid or milky state.

Again, he says (Annual Report, Department of Agriculture, 1865, p. 312):

Until recently, the opinion has prevailed, that cane for making sugar should be thoroughly ripe; that it could not remain standing in the field too long, provided it escaped the frost: but, lately, this notion has been somewhat modified. * * * Something like a case for early or premature harvesting has been made out. The matter can not, however, be considered as definitely settled, until the results of the season of 1866 shall have been determined. After the next year, it will be fully understood. The precise stage of maturity most favorable for the production of crystallizable sugar, according to the new theory, is just after the seeds are formed, and before they begin to harden.

j. Prof. Henry Erni, chemist, Department of Agriculture, 1865, p. 48, says:

Contrary to my expectations, I found that the expressed sorgho juice of ripe cane, whether neutralized by lime or not, refused to crystallize; for what solidified or granulated after long standing of the syrup, was grape sugar.

And, in a foot-note, he says:

The juice from unripe cane readily crystallized.

k. In a pamphlet entitled "The Sorgho Manufacturer's Manual," by Jacobs Brothers, Columbus, Ohio, 1866, p. 4, it is stated that

The cane is in the best state for harvesting when part of the seed is beginning to turn black; or, in other words, *when the seed is in the doughy state.*

l. A correspondent of the Department of Agriculture (Annual Report, 1867, p. 359) says:

I take the sorghum (Otaheitana) when just fairly in bloom. In no case do I allow the seed to mature when I wish to make sugar; but, for No. 1 syrup, I let the cane mature.

m. The Sorgho Journal, William Clough, editor, February, 1869, p. 26, speaking of Neeazana, says:

Do not mind the panicle; if the juice has a clear, sweet taste, even if the panicle is only in bloom, cut and work the cane.

Again, p. 92, under an article entitled "Immature Cane best for Sugar," it says:

The theory that cane should be harvested before fully ripe, when designed for sugar, has been further confirmed by the experience of this year. The other idea, that the cane should be fully ripe, was never confirmed by facts.

Page 58, it says:

The weight of evidence, just now, is in favor of cutting as the seed is passing from the milk to the dough state.

Again, p. 73:

Cut the cane as soon as the seeds are formed. * * * Cut the cane as soon as they acquire a clear, sweet taste. This may occur, in some seasons, when the cane is in the flower; and, in other seasons, not till the seed is fully formed.

n. E. W. Skinner, of Sioux City, Iowa, says (Annual Report, Department of Agriculture, 1873, p. 393):

The best syrup is made from cane not fully ripened.

o. In his report on "Early Amber Cane," by Dr. G. A. Goessmann, of Amherst, Mass., 1879, he says, p. 9:

The safest way to secure the full benefit of the Early Amber cane crop, for syrup and sugar manufacture, is to begin cutting the canes when the seed is full grown, yet still soft.

p. In the Sorgho Hand-Book, published by the Blymyer Manufacturing Company, Cincinnati, Ohio, 1880, it is directed, upon p. 8:

The cane should be cut *when the seed is in the dough.*

q. In a "Report on the manufacture of sugar, syrup, and glucose, from sorghum," by Professors Weber and Scovell, of the Illinois Industrial University, 1881, p. 22, they say:

The proper time to begin cutting the cane, is *when the seed is in the hardening dough.*

r. Vilmorin, of Paris, in the *Journal d'Agriculture Pratique,* February 17th, 1881, p. 230, says:

The period during the development of the plant (sorghum) when the juice is purest and richest in sugar, is that which precedes the maturity of the seed. It is at that point when the interior of the seed has the consistence of soft dough, easily crushed under the finger-nail, that the plant should be cut and pressed.

Prompt working of the Sorghum after cutting.

a. Dr. J. Lawrence Smith, in his report (Annual Report, Department of Agriculture, 1857, p. 192), says:

The uncrystallizable sugar forms rapidly after the cane is fully ripe and recently cut.

And again, as the result of his examinations, he says:

Hence, it is evident that no time is to be lost, after cutting, in expressing the juice.

b. D. M. Cook, Mansfield, Ohio (Annual Report, Department of Agriculture, 1861, p. 311), says:

Let the cane fully ripen, if possible. If the cane is fully ripe, it may be worked into syrup and sugar with advantage, as fast as it is cut up; but if the juice is not perfectly matured, it should be allowed to "season" a few days (by having the cane cut up, bound in bundles, and shocked under a barn or shed for a few days).

c. In an article on "Sorghum culture and Sugar making," by I. A. Hedges (Annual Report, Department of Agriculture, 1861, p. 297), he says:

After the canes have been topped, stripped, cut up, and tied in bundles, they may be set up in the open air, or, more preferably, under shelter, and kept for some weeks. Such keeping improves the juice, not only in flavor, but also in saccharine richness, from 1 to 3 degrees B. This improvement takes place upon the same principle, and from similar causes, which determine the sweetening of acid fruit after pulling, viz., the change of gum and starch into sugar.

d. J. H. Smith, Quincy, Ill. (Annual Report, Department of Agriculture, 1862, p. 134), says:

The cane should be cut and brought to the mill and crushed on the same day; and the topping of the cane, and the stripping of the leaves from the stalks, should proceed no faster than it is cut and brought to the mill, if the very best results are desired, and all danger of souring is to be avoided. * * * It is much better, therefore, not to give the cane any rest, after being stripped and topped, till the juice is expressed and run into syrup. * * * When the

cane is ripe, it should be immediately cut; for, if suffered to remain, after it is ripe, in connection with the roots, a deteriorating effect upon the quality and flavor of the syrup will be the result, and, at the same time, the quantity will be greatly diminished.

e. William Clough, editor of the Sorgho Journal, says (Annual Report, Department of Agriculture, 1865, p. 312):

It would be best to allow but little time between harvesting and working the cane, and on no account should it be stored and allowed to remain long in large shocks. It is almost demonstrable, that no cane sugar is developed under any circumstances after the cane is harvested. The changes that occur after the cane is cut, if any, must be in their nature depreciative, consisting in the transformation of crystallizable to uncrystallizable sugar.

f. The Sorgho Manufacturer's Manual, Jacobs Brothers, Columbus, Ohio, 1866, p. 4, directs that

The cane should be cut and shocked in the field, with tops on, and in this condition it may remain several months before being worked up, for the cane matures and forms more saccharine matter.

g. A correspondent (Annual Report, Department of Agriculture, 1867, p. 359) gives his method of working:

I strip, cut, and work up the cane the same day, if possible.

h. E. W. Skinner, Sioux City, Iowa (Annual Report, Department of Agriculture, 1873, p. 393), says:

As soon as matured, cut, pile, and cover with leaves; never allow it to stand, after maturity, in connection with the roots.

i. The Sorgho Hand-Book (Blymyer Manufacturing Company, Cincinnati, Ohio, 1880, p. 8) directs, that

The cane should be cut several days before grinding, as it will be more free from impurities if cured for a few days before going to the mill.

j. Professors Scovell and Weber, in their report, 1881 (Illinois Industrial University), say:

The cane (sorghum) should be worked up as soon as possible after cutting.

The necessity of further investigation of Sorghum.

a. D. J. Brown (Annual Report, Department of Agriculture, 1856, p. 313) says:

Let the same skill, directed by science, be applied to the making of sugar from the sorgho sucré, and we may reasonably expect the happiest results.

b. Dr. J. Lawrence Smith (Annual Report, Department of Agriculture, 1857 p. 192) further says:

On investigating the sugar bearing capacity of the Chinese sugar-cane, the first step required was to ascertain the true chemical constitution of the juice extracted from the plant. From various conflicting statements on the subject nothing satisfactory could be gleaned; some of the best authorities insisting

that there was not any crystallizable sugar in the juice, or but a very small portion, while others, equally as strong, held the contrary opinion.

c. Dr. J. Lawrence Smith (Annual Report, Department of Agriculture, 1857, p. 192) further says:

It is not to be forgotten that sugar making is an art, and can not be practiced by every one with a mill and a set of kettles. * * * What was necessary for the beet root is doubtlessly required for the sorgho, namely, a thorough study of its nature. with a process of extracting the sugar especially adapted to it.

d. J. Stanton Gould, "Report on Sorghum Culture" (Transactions New York State Agricultural Society, 1863, p. 740), says, in view of the discordant testimony concerning the sorghum question:

These conflicting opinions might easily be reconciled by a few well-directed experiments.

Again he says, same page:

After the most careful inquiry, orally and by letter, I am unable to find that any such experiments have ever been made.

Again, he says (p. 747):

These experiments are not conclusive, and the whole question needs a careful and accurate investigation.

e. Dr. J. M. Shaffer, Secretary Iowa State Agricultural Society, says (Annual Report, Department of Agriculture, 1868, p. 515):

The production of sugar (from sorghum) is rather the result of accident than of any well-digested system for its extraction.

From the foregoing discordant statements upon some of the more important points selected for comparison, viz. (1) the kind of sugar found in the sorghum; (2) the best variety of sorghum for the production of sugar; (3) the time for harvesting, and when the maximum of sugar is present in the juice; (4) the prompt working of the canes after cutting, etc., it is not a matter of wonder that the committee of the National Academy of Sciences, in their report on the "Sorghum Sugar Industry," should have said:

It is evident that nothing was definitely determined, even on points where work in the laboratory, and the exercise of analytical skill, were apparently sufficient to settle most doubts, aside from economic questions, relating to methods of manufacture.

Such, we find, was the condition of the "sorghum sugar question" up to a period immediately preceding the researches undertaken by the United States Department of Agriculture, in 1878, by their present chemist, Dr. Peter Collier.

Nor that they should have, in view of the results of these investigations, reported as to the

Value of the research, in a material sense, to the nation.

Aside from the value of this research from a scientific stand-point—illustrating, as it does, the importance of obtaining, from an extended investigation, the facts and their mutual relations in an agronomic problem—the results obtained appear to this Committee to possess a high value, in a material sense, to the nation.

Whether the cultivation of a crop like sorghum, deriving its support largely from the atmosphere and water—since it appears to thrive best upon light soils—may or may not reward the cultivator better than the growth of cereals, it certainly adds a new factor to agriculture, of value, not only as a sugar producing plant, but also as a food plant of no mean quality. It thrives over a very wide area; and, as we have shown, develops in the warm and temperate latitudes more than a single crop per annum, and becomes, certainly, in one of its varieties, perennial.

But the work is also of national importance in its relation to existing industries, and especially to that of the cultivation of the sugar-cane and sugar production therefrom.

In this country the sugar planter has to contend with obstacles unknown to the resident of tropical countries. A greater degree of skill and knowledge is here required for the attainment of the same result that elsewhere is reached through the normal operation of natural causes, almost without effort on the part of the planter. Such skill and knowledge can only be attained by a carefully conducted experimental inquiry, such as this investigation exhibits.

The methods developed in the course of this investigation are also applicable, with but slight modification, to the cultivation of the sugar-cane, and there can be little doubt but that the ultimate effect of such investigations will be to stimulate the Southern sugar planter to similar experiments for the ascertainment of the most favorable conditions for the prosecution of his own special industry, depending on the culture of tropical cane in subtropical climates, where it never attains its its fullest development, and is consequently subject to many adverse conditions unknown in the tropics.

As a work of national importance, calculated directly to benefit widely separated sections of the country, it is one that has been wisely undertaken and encouraged by the Department of Agriculture, and is deserving of every aid that Congress may be willing to grant for its encouragement and prosecution.

The sugar planter of Louisiana and Texas may possibly discover that he has at command, in one or more of the larger varieties of sorghum, which, like the so-called "Honduras," "Mastodon," etc., attain at maturity, say in four or five months, a growth of 18 to 20 feet in height, and a weight of 2 to 5 pounds per stalk, a sugar-producing plant thoroughly adapted to his climate and soil, equal, and possibly superior, in productive capacity of cane sugar, to the "Ribbon," "Red, or "White" cane now grown there, and escaping the perils from frost which always attend the cultivation of the cane in those regions where the season is never long enough to permit its full maturity.

Of the early maturing varities, like "Early Orange," it will be possible, in Southern latitudes, to make two crops of sugar and seed in one season, and

these, alternating with varieties of longer periods, may extend the sugar crop over nearly half the year.*

The late Hon. J. P. Updegraff, of Ohio, in debate, upon the floor of the House of Representatives, declared, that

> The distribution of sorghum seed, by the Department of Agriculture, had brought to the agriculture of this country a greater return than the whole amount which that Department has ever cost since its foundation. Yet it is only a few years since the distribution of sorghum was ridiculed.

And the Hon. J. H. Burrows, of Missouri, in the course of the same debate, declared, that

> The importation and introduction of the sorghum, or African, cane, is one among the many of the practical results of the Department of Agriculture; and, to the people of the North, fell like a blessing from a war-clouded sky.

HISTORY OF THE DEVELOPMENT OF THE BEET SUGAR INDUSTRY IN EUROPE.

To those at all familiar with the early struggles of nearly every great industry, there is nothing surprising in the experiences which those have been compelled to undergo who have labored to develop the sorghum sugar industry. The prejudices of ignorance, the arrogance of conceit, and the malevolence of jealousy, have conspired to belittle and misrepresent, to hinder and obstruct every attempt, to ridicule, rather than encourage: such has been the reception which has been accorded to those who have taken the lead in this enterprise.

The history of the development of the beet sugar industry, presents much to encourage those who have engaged in the efforts to produce sugar from sorghum and maize; and a brief account will interest and encourage those who hope to see sorghum sugar produced in sufficient quantity to supply all our wants.

In 1747, Margraff, a member of the Berlin Academy of Sciences, succeeded in securing from the beet root crystallizable sugar; and he

* We cite, in this connection, the following letter from Col. H. B. Richards, of La Grange, Texas:

"But now let me tell you about my Orange cane. It is no longer doubtful at all but that the Orange cane will become, in this climate, perennial; and, after this year, I will only plant every two years. I have tested it now effectually for two years, and am convinced that the stubbles will stand colder weather, and more of it, than those of the Ribbon cane.

"My cane, from last year's stubbles, has larger stalks, is taller, and, in every way, ahead of the earliest seed cane at this time. * * *

. . . .

"Yours truly,

"HENRY B. RICHARDS.

"La Grange, Fayette County, Texas, April 8th, 1882."

urged upon the Academy the importance of his discovery, believing that Europe would find in this root the basis of an immense industry. But his important results appear to have been forgotten, until nearly a half century later, his pupil, Achard, again took up the work of his master, and produced from beets a considerable quantity of sugar. In 1797, he published his results; and, in 1799, presented a sample of the sugar, and submitted his method for its extraction, to the Institute of France. The interest aroused in the Institute was such that a commission was appointed by the Institute to examine the results and methods of Achard, and to repeat his experiments. This commission consisted of MM. Cels, Chaptal, Darcet, Fourcroy, Guyton, Parmentier, Tessier, Vauquelin, and Deyeux, names eminent in the annals of science.

The report of this committee, although fully sustaining the methods and results of Achard, was without apparent result until nearly ten years after, when M. Deyeux, one of the committee, at the request of the Minister of the Interior of France, again repeated the work of Achard, and was again successful in obtaining "sugar perfectly crystallized, of great whiteness, brilliant, and sonorous—in a word, enjoying all the properties of the finest cane sugar."

About the same time, MM. Barruel and Isnard undertook experiments for the determination of the quantitative and economical aspects of this question, and found that they were able to extract *one and one-half per cent* of Muscovado sugar, at a cost of thirty cents per pound, while the refined sugar cost forty cents per pound.

February 20th, 1811, the Société l'Encouragement pour l'Industrie Nationale received samples of beet sugar produced by M. Drappiez, a pharmacist of Lille, who also, in a memoir, laid before this society his methods for its extraction.

M. Drappiez obtained by his method *one and three-tenths of one per cent* of sugar from the beet root, at an estimated cost of eighty cents per pound. About a month later (March 25th, 1811), Napoleon issued his first decree, now famous for the encouragement and the impulse it gave to this struggling industry. By this decree, there was appropriated one million francs ($200,000) to provide for the planting of 32,000 hectares (79,040 acres) in beets; "for the establishment of six experimental schools, for giving instruction in the manufacture of beet sugar, conformably to the processes of chemists;" as also for the experiments and instruction in processes for the manufacture of indigo. In addition, it was decreed, that the importation of sugar and indigo from England and her colonies should be prohibited. It is interesting to observe that, at this time, the value of the sugar and indigo imported into France

amounted to 100,000,000 francs ($20,000,000), so that the amount appropriated for the encouragement of efforts to produce these two commodities amounted to *one per cent* of the amount paid for them to foreign countries. In 1882, the United States imported over one hundred million dollars worth of sugar and molasses, and the duties paid upon the same amounted to more than fifty million dollars additional; and the amount appropriated by Congress for the purpose of investigations on sorghum was *ten thousand dollars.*

It is also interesting to observe, that the six experimental schools established were "to give instruction in the manufacture of beet root sugar, *conformably to the processes of chemists.*" This tells the whole story: it fully explains how, from such small and unpromising beginnings—from a root inferior, in every way, to the tropical cane—from the production of sugar costing eighty cents per pound—this industry has developed to that degree, that the beet root is to-day, and for many years has been, the only rival of the sugar-cane in producing the world's supply of sugar. The acorn has become the oak. The predictions of Margraff, in 1747, are to-day accomplished facts. Europe *has* found, in the beet root, the basis of an immense industry. The reason for this, is found in that decree of Napoleon—than whom, whether in peace or in war, Europe has never had his superior in the field—the decree of Napoleon, that the manufacture of beet sugar should be taught in the schools "*conformably to the processes of chemists.*"

The beet sugar industry is one of the proudest triumphs of science. About its cradle, all the sciences have stood as foster parents; and improved methods, improved machinery, improved cultivation, improved varieties, have marked each step of its progress. But for the careful supervision of science, its present proportions were impossible: and so soon as that supervision shall be withdrawn, or shall be given in equal measure to the production of sugar from sugar-cane or sorghum the beet sugar industry must inevitably perish; but its history has shown the value of science to the arts, and has done much to silence the sneers of the ignorant at laboratory work. As evidence of the rapid development of this new industry, we may recall that there was produced in France, from beets, in 1826, only 1,500 tons of sugar, and in 1875, 462,259 tons; and, at the present, 38 per cent of the world's supply of sugar is obtained from beets, and 62 per cent from the sugar-cane.

NECESSITY FOR FURTHER RESEARCH.

To those engaged in the development of the sorghum sugar industry, it is hardly necessary to say, that, great as are the strides which have been made during the past few years in our knowledge of sorghum as

a sugar producing plant, there yet remains many questions of the greatest practical value, concerning which we know very little indeed; and it is to be hoped that we have long ago ceased to speculate, when accurate and repeated experiments alone can assist us in a correct solution of these questions.

It is proposed to indicate a few of the more prominent questions connected with this industry, which are of practical importance, and await solution.

It must not be forgotten that, owing to the number of conditions which affect each experiment, but few of which we may take cognizance, that no conclusion may be safely drawn from one, or even many results; but, at the same time, every carefully recorded observation is of value, and will serve in the final determination of the truth. Not alone in this, but in every other inquiry is it true, that hasty generalizations are the very bane of science; and yet we have seen how this unfortunate tendency has retarded the development of this industry for over a quarter of a century. From a single poorly conducted experiment, it was decided that, practically, no sugar could be made from sorghum, owing to the inversion of the sugar, which, through some mistaken method of manufacture, resulted in this one case. From the examination of a single one of the hundred varieties of sorghum, the sweeping conclusion was published, by one who should have been an authority in agricultural science, that no variety was of any value for the production of sugar. Through imperfect methods of testing, one finds the seed of sorghum a rival of tan bark in its contents of tannic acid, despite the fact that such a discovery would render sorghum unique among the cereals; another fails to find in the juice of sorghum a trace of glucose, although it is never absent; while still another bases a method for the extraction of sugar upon his discovery (?) of crystals of sugar in the fresh stalks of sorghum. Let each remember that, for every incorrect observation or result reported, there is necessitated at least ten times the labor to disprove it—and they may be less disposed, without repeated confirmation, to *publish*, although it is to be hoped they will not neglect to *record*.

Above all, let us not consider that we are bound, at the present, to profess complete knowledge concerning the entire subject; for we may feel no hesitation in confessing our ignorance, which our attempts to conceal makes too evident.

At a recent meeting of sorghum growers, the question as to the soil best adapted for the cultivation of the plant was under discussion. All must admit that is a question of extreme practical importance. After a long discussion, with the presentation of as many views as

there were speakers, it was at last settled, by the passage of a resolution, that such and such and such a soil was the best adapted for the growth of sorghum. Than this, nothing could be more unwise, more unscientific, or more utterly foolish. As well might the convention have resolved that a solar eclipse should take place the next week or the next month. Accumulated facts, and not resolutions, are imperatively demanded. A leading agricultural writer, not long ago, declared, that "the conversion of amber cane (one of the varieties of sorghum) into crystallized sugar of standard excellence, in paying quantities, and with a fair margin of profits to all concerned, is a result not only never yet reached, but made *simply impossible by the force of natural laws.*" Strong words, indeed; and yet, within three months of the time the above was written, there was produced, within 300 miles of this paragrapher, notwithstanding the forces of nature he had so confidently declared as in opposition, 160 tons of excellent sugar, at good profits, mainly from the very variety he had named as being incapable of yielding sugar. This new industry has very much conservatism of such sort to contend with. It has, also, beyond doubt, many practical problems yet to solve; but this may be confidently asserted, that, thus far, there has nothing presented itself which has long stood in the way of an advance, which, during the past three years, has been most remarkable.

As with the beet sugar industry, many experiments have proved failures; and many persons have been found, as then, who, from the first, have declared that the manufacture of sugar from sorghum was a commercial impossibility. But, in spite of adverse criticisms, partial failures, and the opposition of interested parties, the beet sugar industry in Europe has been, and to-day is, one of the greatest industries of that country; and, as we have seen, provides, at a profit more or less great, fully two-fifths the sugar of the world. It must not be, however, supposed, that all the practical questions which may arise shall prove as of easy and speedy solution as those, the solution of which have sufficed to place the sorghum sugar industry fairly upon a basis of profit.

The development of any new industry of great magnitude, and involving so many conditions conspiring to help or hinder its greatest success, is sure to bring to light many important questions bearing upon the cheapening and simplification of manufacturing processes, the many questions concerning the cultivation and management of the crop, which the results of only a series of years of observation and experiment can bring to a reliable conclusion.

That it is a wise and enlightened policy for this government, whether state or national, to encourage in every legitimate way the thorough investigations of these great economic questions, which have so much

to do with the material prosperity of the country, seems hardly a question admitting an intelligent doubt. Already New Jersey and Massachusetts have by means of bounties stimulated experiments in this direction, which, in New Jersey at least, have already led to most important results.

New Jersey, in an "Act to encourage the manufacture of sugar in the state," provides, that one dollar shall be paid by the state to the farmer for each ton of material out of which crystallized cane sugar has actually been obtained; and it provides, also, a further bounty of one cent per pound to be paid to the manufacturer for each pound of cane sugar made from such material. Massachusetts passed an act providing that one dollar be paid for each 2,000 pounds of sorghum cane, or sugar beets, used in the state for the manufacture of sugar.

Several of the states have, by appropriations, provided for the continuance of investigations looking to the economical production of sugar. The general government has for the past two years, in spite of a persistent and determined opposition from a source as surprising as it has been inexplicable, continued to make appropriations for the prosecution of those investigations, which have already resulted in the accumulation of most of the facts which are thus far established beyond question, and which have been recorded in these pages.

In the words of the Committee of the National Academy of Sciences, "the fruits of this policy of the general government are already beginning to show themselves in the decided success which has attended the production of sugar from sorghum on a commercial scale in the few cases in which the rules of good practice, evolved especially by the researches made at the laboratory of the Department of Agriculture, have been intelligently followed," and they conclude their report in these words: "The sugar producing industry of the whole country, both that of the tropical cane in the South and the sorghum over a far wider area, will derive yet greater benefits from the continued investigations of the chemist of this department, to whose former work we are already so much indebted."

A few of the points which are at present awaiting investigation, may be briefly summarized. Even granting that the questions already settled have sufficed to place this new industry upon a safe and profitable footing, it by no means follows that it may not be made far more profitable. To this end there yet remains a vast amount of work demanding further investigation.

The unanimous testimony of sugar manufacturers conclusively proves, that, at present, fully one-third the sugar present in the cane or sorghum is lost through the imperfect methods for its extraction.

That such a loss is permitted to continue, is a reproach to the industrial science of the country.

The variety of soil best adapted to the development of sorghum; the effect of the various fertilizers upon the several varieties of soil; the effect of our climate and soils upon the sugar producing capacity of the many varieties of sorghum; the effect of various methods of cultivation of the plant; the possibility of producing by skillful hybridization varieties more valuable than any now known; the growing and examination of varieties as yet unknown to this country; the various methods of defecation and their relative value; these, and many similar questions, will at once arise to the mind of any one familiar with what has already been accomplished.

Concerning each and all of these important questions, our knowledge at present is almost nothing.

In view of the wide area over which this plant may be grown in this country, with the great diversities of climate, it is by no means improbable that a variety of sorghum may be developed, combining the excellencies of several and surpassing any now known. Such results have been secured with the beet, so that the average per cent of sugar present in the best varieties now grown, has been increased one or two hundred per cent over that originally present in the root. Certainly, with such results already the reward of investigation, it is to be confidently anticipated that no efforts will be spared that similar results may reward those engaged in the investigation of the sorghum, a plant which is most remarkable for the great adaptability it possesses, as evidenced by the numerous varieties grown in every quarter of the globe. Even while engaged in writing, the author has received several varieties of seed from Asia and Africa, wholly new to this country, and mention has been made in this volume of some twenty or more varieties from southern Africa, quite unlike any previously grown in America.

The practical determination of what is known as "available sugar," is also a matter of great importance; since it may be found that the methods for its estimation in the juices of the sugar-cane and the beet, are inapplicable to the juices of sorghum.

In the purging of sorghum and corn-stalk sugar, it happens very often that this operation is of unusual difficulty, owing to the presence of a certain gummy substance; and this practical difficulty has been by some so magnified, that the economical production of sugar from these two plants has been confidently declared impossible.

In the experience at Washington, as well as that at many other places, this peculiar substance has been found often to be present in

quantity so small as to offer little, if any, resistance to complete purging in the ordinary centrifugal.

It is a matter of very great practical importance, to determine those conditions which prevent its being produced in the manufacture of the syrup; since in no case has its presence been detected in the freshly expressed juices of either sorghum or maize. It appears to be formed by transformation of other constituents of the juice in *the progress of syrup production.*

In fact, unless the sorghum sugar industry shall prove to be unlike any other which has been developed, we may safely predict that many questions similar to the above will, from time to time, arise and demand solution.

It is worse than idle to dogmatize upon such questions; but dogmas will prevail in the future, as in the past, where carefully ascertained experimental results are wanting, and it is only the results of careful research which can clear the way to the establishment of this industry upon the basis of the greatest economy.

To such an end whoever contributes, even in the least degree, may consider himself a public benefactor; and whoever, either through ignorance or wickedness, shall hinder the consummation of a result so greatly to be desired, shall receive, as he will most justly deserve, the execration of his fellow men.

FUTURE PROSPECTS OF THE SORGHUM SUGAR INDUSTRY.

From the results already secured and recorded in this volume, there would appear no good reason to doubt, that, within a few years, we may render ourselves wholly independent of other nations for our sugar supply.

It may appear somewhat hazardous to venture any prediction; but I think such a result will be accomplished within the next decade, and that, by 1900, we shall export sugar produced from sorghum to Europe. That such a result appears possible, yes, most probable, rests upon these few well established facts:

1. About 38 per cent of all the cultivated land in the United States, including the grass land, is at present devoted to the cultivation of maize: thus showing that the conditions of soil and climate in our country conspire to make the production of maize profitable.

2. The demands made upon the soil, and the conditions of climate necessary to the full development of sorghum, are practically identical with those made by and necessary to maize.

3. The methods of cultivation of the two crops are identical; so

that, in every township of the country, these methods are practically understood.

4. The greater part of the maize consumed in this country, is used for the purpose of feeding and fattening swine; and numerous analyses of several different varieties of sorghum seed, have shown that the proximate chemical composition of sorghum seed is identical with that of maize, the sorghum seed differing no more from maize in composition than does one variety of maize from another.

5. Numerous feeding experiments have established the fact, that, for feeding and fattening purposes, sorghum seed is the equivalent of maize, and may be substituted for it.

6. As much sorghum seed may be produced from an acre as of maize, on the same land; and wherever maize may be grown successfully in this country, one variety or another of sorghum may be as successfully grown.

7. Fully ninety-nine per cent of the sorghum now grown in the world, is grown solely for the seed and the forage obtained in the leaves; and abundant testimony is given, that, for the seed alone, the crop may be profitably grown, while many of those using the stalks for syrup and sugar declare that the seed enables them to produce the stalks free of all cost.

8. It is only after the seed of any variety of sorghum is quite mature, that the maximum of sugar in the stalks is attained; so that there is nothing to prevent the securing of both the maximum of seed and the maximum of sugar from the crop of sorghum.

9. Many thousands of analyses of over fifty varieties of sorghum have conclusively established the fact, that, at maturity, the stalk of sorghum contains an amount of sugar equal to that found in the best sugar-cane grown in Louisiana; and already, by processes and apparatus identical with those employed upon the sugar plantations of Cuba and Louisiana, several hundred tons of sorghum sugar have been put upon the market in competition with sugar from the tropical sugar-cane.

10. The testimony of numerous manufacturers of syrups from sorghum, shows that the syrup may be manufactured at an expense varying in different localities, and with different manufacturers, from 12 to 25 cents per gallon, from cane delivered free at the mill, even when working with small mills instead of the improved appliances of the large plantations.

11. A yield of 6 to 8 pounds of sugar from the gallon of syrup, made at the proper time, may be fairly expected; and thus the sugar would cost, according to the expense of manufacture above given,

from $1\frac{1}{2}$ cents to 4 cents per pound, without any allowance for the molasses.

12. Excellent sugar has been made from sorghum: and where accurate account of all expenses was kept, including cultivation of crop, but no account made of the seed, the expense of production of the sugar did not exceed $4\frac{1}{2}$ cents per pound.

13. In view of these results, I have no doubt that sugar may even now be produced at an expense of not over 2 cents per pound; and I believe that, within a decade, it will be produced at an expense of not over 1 cent per pound.

CHAPTER II.

(*a.*) Chemistry of Sugar.
(*b.*) Sources of Sugar.
(*c.*) Statistics of Sugar.
(*d.*) Bibliography of Sorghum.

CHEMISTRY OF SUGAR.

Under the name, sugar, the chemist includes a number of different organic compounds, most of them being vegetable in their origin. They are all soluble in water, though in different degrees; and are all characterized by a sweet taste, though possessing different degrees of sweetness.

They are neutral in their reactions with vegetable colors; but, in the compounds they form, play the part of acids. They are all remarkable for their effects upon a beam of polarized light, which, when passed through solutions of any one of the sugars, is rotated to the right or the left. The direction and the degree of rotation is constant under the same conditions of density of solution and temperature for the several sugars.

The principal members of this group of sugars, are:

1. Cane sugar; also known as sucrose and saccharose, $C_{12}H_{22}O_{11}$. This sugar is found present in the juices of the sugar-cane, Saccharum officinarum; maize, zea mais; sorghum, Sorghum saccharatum; beets, Beta vulgaris; sugar maple, Acer saccharinum; several species of the palm, and many other plants.

The pure sugar, from either of the above sources, is identical in all its properties—as crystalline form, chemical composition, degree of solubility, sweetness, and rotatory power.

2. Glucose, $C_6H_{12}O_6$. Under this name is grouped two principal compounds: (*a*) Dextro-glucose, or Dextrose, which rotates the polar ized beam to the right; and (*b*) Laevo-glucose, or Laevulose, which rotates the beam to the left.

Dextro-glucose is known as grape sugar, starch sugar, fruit sugar, honey sugar, diabetic sugar, according to its source.

Sweet fruits and honey contain this form of glucose, associated with cane sugar and laevo-glucose.

Laevo-glucose has the same chemical composition as dextro-glucose; but is distinguished by its left-handed rotatory power. This form of

glucose is obtained, together with dextro-glucose, in the fermentation of cane sugar, which, under the action of the ferment, splits up into equal parts of dextro and laevo-glucose. And, since the left-handed rotation of the latter is greater than the right-handed rotation of the former, the solution of cane sugar—which, at first, was right-handed in its rotation of the plane of polarized light—after fermentation is found to be left-handed, or (as it is termed) inverted; and hence the name "inverted sugar," which is a mixture of these two forms of glucose.

The formula which represents the final results in this process of fermentation is, in

$$\begin{array}{cccc} \text{Cane sugar} + \text{water.} & & \text{Dextro glucose.} & \text{Laevo-glucose.} \\ C_{12}H_{22}O_{11} + H_2O & = & C_6H_{12}O_6 & + \ C_6H_{12}O_6. \end{array}$$

One molecule of cane sugar uniting with one molecule of water, and then breaking up into one molecule of dextro- and one molecule of laevo-glucose.

This change in cane sugar is readily brought about, also, by the action of dilute acids. If, to a dilute solution of cane sugar, a few drops of sulphuric or hydrochloric acid be added, and the solution be heated at a temperature of 90°C. (194°F.) for half an hour, it will be found that the cane sugar will have entirely disappeared from the solution, and, in its place, will be found its equivalent of inverted sugar. This is the method pursued in the determination, by analysis, of the cane sugar in juices of sugar producing plants. (See chapter on Methods of Analysis.)

It is, however, to be remembered, that this change is effected by the heat *in the presence of an acid*, and very speedily in such circumstances: but heat alone effects this change very slowly, indeed, if at all; although the contrary opinion is very generally entertained by those who have never subjected the matter to the test of experiment.

A series of experiments are given in the Journal Fabr. Sucre, by M. Pellet, showing the amount of inversion of solutions of cane sugar at diferent temperatures and degrees of concentration. The experiments were, in each case, continúed for four days (96 hours):

Sugar in 100 c.c.	At 25° C.	At 50° C.	At 75° C.
10 grams.	.5975 grams.	3.0216 grams.	8.8100 grams.
30 grams.	.5275 grams.	2.9200 grams.	7.1825 grams.
60 grams.	.1025 grams.	.6450 grams.	5.4900 grams.
90 grams.	trace.	.1500 grams.	3.9776 grams.

It will be seen, that the extent of inversion was dependent upon temperature and concentration of the solution; and that a solution containing 60 grams. of sugar in 100 cubic centimeters of solution (about the consistency of a syrup), even after four days' heating at a temperature

of 75°C. (177°F.), had only 5.49 grams. of the sugar inverted, or 9.15 per cent of the amount; so that, in ordinary work, the inversion of sugar by heat alone may be regarded as very slight.

In the presence of a slight excess of lime, it has been found that a solution of cane sugar remains unchanged, even after prolonged boiling for thirty-six hours. The practical importance of this fact is obvious to the sugar manufacturer, since, by proper defecation with lime, the acids present in the saccharine juices of plants are neutralized and rendered inert.

3. Lactose, or milk sugar, $C_{12}H_{22}O_{11}$.

This sugar is that which gives to milk its sweet taste.

Lactose, although having the same composition as cane sugar, differs from it very greatly in all its properties, in crystalline form, degree of solubility, and sweetness, and in its rotatory power, which, though right-handed as is that of cane sugar, is far less in degree—the relative degrees of rotatory power of the four sugars mentioned being as follows:

Cane Sugar,	right-handed		73°8
Milk	"	"	59°3
Dextrose,	"	"	56°
Laevulose,	left	"	106° at 14° C
"	"	"	53° at 90° C

Lactose, also, in ordinary fermentation, produces Lactic Acid instead of glucose. The formula representing the results of the fermentation, being:

$$\text{Lactose} + \text{Water} = \text{Lactic Acid.}$$
$$C_{12}H_{22}O_{11} + H_2O = 4\ C_3H_6O_3$$

The one molecule of lactose taking up one molecule of water and being then broken up into four molecules of lactic acid; this result constituting what is known as the souring of milk.

The relative solubilities of these several sugars in cold water, are as follows:

1 part	Cane Sugar	in	⅓ its weight of water.
1 "	Glucose	"	1⅓ " " "
1 "	Lactose	"	5 times its weight of water.

Cane sugar is readily obtained in crystals by the evaporation of its solution in water, as in the familiar form of the so-called granulated sugar, which may be seen to be composed of well defined crystals, also in the well known form of rock candy, in which crystals an inch in diameter are often found.

Glucose also crystallizes both in its anhydrous form, and also in combination with water. The crystals of glucose, however, are generally a collection of minute needles clustered into granular masses, or, if the solution is concentrated, uniting to form a semi-solid mass; as

frequently occurred in the earlier efforts in making commercial glucose, where the fluid syrup, after standing a short time, was found to have been entirely changed into a solid mass of crystals of hydrated glucose.

Lactose is easily obtained crystallized, although the form of its crystals, its comparative insolubility, and its low sweetening power, will enable one to readily distinguish it from either of the other sugars mentioned.

It is also to be observed, that each of these sugars are composed only of carbon, hydrogen, and oxygen; the last two elements existing always in the proportion to form water, and hence the name carb-hydrates which has been applied to compounds of this class. Since, now, these three elements exists in the atmosphere in inexhaustible quantity, it will be seen that the production of sugar need necessarily never result in the exhaustion of the soil.

This matter will be hereafter discussed.

SOURCES OF SUGAR.

It has been already stated that cane sugar, or sucrose, is found in the juices from the stalks of the sugar-cane, maize, sorghum, and many similar plants; also in the juices of the beet root, the sap of the sugar maple, and of many species of the palm. It is, besides, a constituent of honey, and of fruits.

A comparatively small amount is obtained from the palm, while the maple sugar is an article of local consumption.

It is estimated that, in 1850, there was exported of palm sugar 10,000 tons from that portion of North-eastern India lying near the mouths of the Ganges. About 20,000 tons of maple sugar is produced annually in the United States, in 18 states.

The commercial supply, however, of this important product, is obtained almost exclusively from two sources, viz: the several varieties of the sugar-cane, and the beet root, the former furnishing about 62 per cent, and the latter 38 per cent of the world's sugar.

The actual production of cane sugar in tons in the years 1875, 6, 7, 8, 9, 80, was as follows:

	1875		1878.
From Sugar-cane	3,395,478	From Sugar-cane	3,395,478
" " Beets	1,168,281	" " Beets	1,398,051
	1876.		1879.
From Sugar-cane	3,292,137	From Sugar-cane	3,550 390
" " Beets	1,350,731	" " Beets	1,549,224
	1877.		1880
From Sugar-cane	3,337.410	From Sugar-cane	2,327,000
" " Beets	1,103,466	" " Beets	1,670,000

NOTE—SEE APPENDIX.

The several countries producing this supply, are as follows:

Cane.	1875.	*Cane.*	1875.
Cuba	700,000 tons.	Peru	50,000 "
Porto Rico	80,000 "	Egypt	40,000 "
British, Dutch, and Danish West Indies.	250,000 "	Central America, and Mexico	40,000 "
Java	200,000 "	Reunion	30,000 "
Brazil	170,000 "	British Isles and Penang	30,000 "
Manilla	130,000 "	Honolulu	10,000 "
China	120,000 "	Natal	10,000 "
Mauritius	100,000 "	Australia	51,000 "
Martinique & Guadaloupe	100,000 "	Total	2,186,000 "
Louisiana	75,000 "		

Beet Sugar.	1875.	*Beet Sugar.*	1875.
German Empire	346,646 tons.	Belgium	79,796 tons.
France	462,259 "	Holland and other countries	30,000 "
Russia and Poland	245,000 "		
Austria and Hungary	153,922 "	Total	1,317,623 "

The Consumption per capita of Sugar in the World.

The amount of sugar consumed per capita differs very greatly, and represents to a certain extent the relative degree of luxury of the several countries.

According to the statement of Lock, Wigner & Harland, the following represents approximately the number of pounds annually consumed in the several countries per capita:

		Aggregate Consumpt'n cwt.	pounds per head.			Aggregate Consumpt'n cwt.	pounds per head.
Australia	1874	1,713,142	85 90	France	1874	5,000,000	15 50
Great Britain	1875	18,374,543	62 80	Austria, Hungary	1874	3,400,000	15 10
British America	1875	1,721,386	51 40	Norway	1873	193,086	12 70
River Plate States	1874	1,000,000	43 90	Portugal	1874	300.000	8 40
United States	1873	13,040,500	37.80	Brazil	1874	642,857	8 00
Denmark	1873	533,831	33 30	Greece	1871	86,800	6 60
Holland	1874	800,000	25 03	Peru	1874	570,000	5 61
Belgium	1874	1,000.000	23 19	Russia and Poland	1874	4,000,000	5 40
Sweden	1873	630,741	16 90	Turkey	1874	500,000	3 80
Germany	1874	6,120,000	16 60	Italy	1873	865,350	3.60
Switzerland	1873	381,295	15.90	Spain	1873	81,817	.54

Countries Supplying United States with Sugar.

	Pounds.	*Value.*		*Pounds.*	*Value.*
Cuba	1,008,413,671	$41,039,048	Dutch E. Indies	26,187,830	1,052,953
Spanish Possessions	110,445,708	3,572,400	British W. Indies and Honduras	23,212,168	844,144
Porto Rico	70,155,045	2,610,418	British Guiana	21,865,691	912,101
French W. Indies and Guiana.	49,687,265	1,751,458	Sandwich Islands	20,978,374	1,051,987
Brazil	40,010,416	1,329,938			

The above are the principal sources. Twenty-one other nations furnish the remainder, which constitutes about 3 per cent of the whole amount.

From the statistics it appears, that, during the past 20 years, the United States have produced less than 13 per cent of their sugar supply, and little more than 21 per cent of the molasses consumed.

Sugar Product of Louisiana, 1823–1877.

AMERICAN ALMANAC, 1880, p. 32.

	Hogsheads.		*Hogsheads.*
1823	30,000	1855	231,427
1824	32,000	1856	73,296
1825	30,000	1857	279,697
1826	45,000	1858	362,296
1827	71,000	1859	221,840
1828	88,000	1860	228,753
1829	48,000	1861	459,410
1832	70,000	1863	76,801
1833	75,000	1864	10,387
1834	100,000	1865	18,070
1835	30,000	1866	41,000
1836	70,000	1867	37,647
1837	65,000	1868	84,256
1838	70,000	1869	87,090
1839	115,000	1870	144,881
1840	87,000	1871	128,461
1841	90,000	1872	108,520
1842	140,000	1873	89,498
1843	100.000	1874	116,867
1844	200,000	1875	144,146
1845	186,000	1876	169,331
1846	140,000	1877	127,753
1847	240,000	1878	213,221
1848	220,000	1879	169,972
1849	247,923	1880	218,314
1850	211,201	1881	122,982
1851	236,547	1882	241,220
1852	321,934		
1853	419,324		
1854	346,635		

Average weight of the hhd. is reckoned at 1137 pounds net.

Average Yield of Sugar per Acre.

	Pds.	Maximum reported.		Pd.	Maximum reported.
Demerara	4,480		Louisiana	1,200	
Mauritius	3,500	5,500	Queensland	2,958	7,840
Philippines	1,680	2,800	Natal		7,000
Java, about	3.360		Sandwich Islands		12,000
Rio Janeiro	2,100		Figi		5,000
Jamaica	1,344	5,600	Surinam	1,960	
India, average	896				

The following statistics of the acreage and production of sugar and molasses in the United States, is from the Annual Report of the Department of Agriculture.

Sugar-cane.

(1879 Census.)

States.	Acres.	Sugar. *Hhds.*	Molasses. *Gallons.*	States.	Acres.	Sugar. *Hhds.*	Molasses. *Gallons.*
Alabama	6,627	94	795,199	Mississippi	4,555	18	536,625
Florida	7,938	1,273	1,029,868	South Carolina	1,787	229	138,944
Georgia	15,053	601	1,565.784	Texas	10,224	4,951	810,605
Louisiana	181,592	171,706	11,696,248				
				Total	227,776	178,872	16,573,273

Maple Sugar.

Lewis S. Ware gives the following table, showing the total product of maple sugar in the United States:

1861	42,000,000 pounds.	1870	28,443,645 pounds.
1862	44,000,000 "	1871	30,756,000 "
1863	41,500,000 "	1872	31,682,000 "
1864	40,500,000 "	1873	32,157,000 "
1865	39,740,796 "	1874	33,044,200 "
1866	37,532,000 "	1875	43,197,930 "
1867	35,654,000 "	1876	43,288,080 "
1868	33,421,000 "	1877	41,000,000 "
1869	29,114,500 "		

Of this amount, over 50 per cent is produced by the states of New York and Vermont, 20 per cent by Ohio and Michigan, while the remaining 30 per cent is divided between 14 of the northern states.

Production of Sugar from Sugar Beets.

France.—Authority, Corenwinder and Macarez, Lille (Special Report, Department of Agriculture, on "Culture of the Sugar Beet"):

FROM 2,200 POUNDS ROOTS.

	Pounds Sugar.	*Pounds Molasses.*
1873–4	124.74	79.20
1874–5	128.26	74.80
1875–6	117.04	80.96
1876–7	97.68	69.96
1877–8	133.65	77.88
Average	120.27	76.56

Equal to 5.47 per cent sugar from beets.

From "A Complete Treatise on the Fabrication and Refining of Beet Sugar," by L. Walkoff, we learn that the average per cent of sugar from beets, in 1872–3, was, in *Russia* and *Poland*, 7.0 per cent.

Germany..8.5 " "
Austria and Hungary........................9.6 " "

During the season of 1879–80, there were worked in Germany 4,628,748 tons of beet roots for sugar. The average product per acre was 11.09 tons of roots. From 1,174 tons of roots there was obtained 100 tons of all sugars, or 8.52 per cent of the weight of roots. This yield is equal to 1,890 pounds of all sugars to the acre.

The following tables give the statistics of the production, importation, and consumption of sugar and molasses in the United States from 1790 to 1882, inclusive.

From 1878 to 1882, inclusive, no allowance is made for sorghum or maple sugar, owing to the lack of reliable statistics as to their production. Since 1878, the amount of sorghum and maple molasses is estimated at 15,000,000 gallons of the former, and 2,000,000 gallons of the latter, although the production of sorghum syrup is probably very largely in excess of the above estimate at the present time.

The tables are taken from the Report of the Department of Agriculture for 1878.

Explanations and Remarks on the Tables.

In making thorough examination of the question of sugar production in the United States, a collateral inquiry has resulted in information which is appended at this time, for the attention, not only of the legislative powers of the country, but of all

those interested in commercial transactions with sugar and its allied products.

The tabular statement of the tariff on sugar, extending from 1790 to 1882, inclusive, compiled with care, has been subjected to such revision, as, I believe, entitles it to the confidence of those who wish to investigate this subject, or to predicate legislation thereon.

The *Imports* and *Exports* are taken or compiled from the "American State Papers" and the statistics of "Commerce and Navigation."

The "*Difference*" is obtained by subtracting the exports from the imports, or the reverse; if the export item exceeds the import item, a minus sign is used to designate such excess.

"*Value*" signifies the difference between the value of the imports and the value of the exports, and is, therefore, the cost of what is consumed. From 1867 to the present date, the amounts in the value column are quoted from the statistics of "Commerce and Navigation."

"*Price*," or "*Average per pound*," is obtained by dividing value by the quantities in the column of foreign consumption.

The annual amounts "*Paid for customs*" from 1867 until date, are quoted or compiled from the statistics on "Commerce and Navigation;" previous to that year, they are found by multiplying the quantity consumed by the rate of duty on each kind or grade of the article under consideration. For instance, refined sugar comprises different grades, with a corresponding variety in the rates of duty.

The "*Rate*," or "*Average rate of duty*," is the result of dividing the *Paid for customs* by the amount consumed.

The column of *Domestic produce* is estimated and collected from various sources, and, although not absolutely correct, forms the best known data of the sugar produced in the United States.

The figures in *Domestic exports* are quoted from the "American State Papers" and statistics of "Commerce and Navigation."

Previous to 1867, *Foreign consumption* is deduced from the imports and exports; after that time, the amounts are taken from the tables of home consumption in the statistics of "Commerce and Navigation."

Domestic consumption, previous to 1867, is the difference between domestic production and exports; subsequently, the amounts are copied from the statistics of "Commerce and Navigation."

Total consumption and *Average per capita* are interesting and important, as showing the rate of increase in the consumption of sugar with the increasing population; also, the fluctuations from year to year, caused by changes in the tariff laws, or by wars or other disturbances.

TABLE

Imports, Exports, Cost, Production, and Consumption of Cane, Maple, and Sor-

Years.	Foreign.			Value of Foreign Sugar Consumed.	
	Imports.	Exports.	Difference.	Value.	Paid for Customs.
FIRST DECENNIUM.	*Pounds.*	*Pounds.*	*Pounds.*	*Dollars.*	*Dollars.*
1790	18,229,419	49,787	18,179,632	(c)	185,649
1791	24,901,639	75,661	24,825,978		383,234
1792	*a* 24,420,372	1,197,916	23,222,456		355,969
1793	*a* 47,762,505	4,611,988	43,150,517		688,812
1794	*a* 48,705,900	20,762,221	27,943,679		469.847
1795	63,783,405	22,117,267	41,666,138		651,101
1796	59,469,154	35,832,790	23,636,364		355.789
1797	72,765,821	38,570,051	34,195,770		589,567
1798	87,523,918	51,740,717	35,783,201		641,247
1799	103,846,468	79,054,040	24,792,428		3,026,964
SECOND DECENNIUM.					
1800	113,339,751	56,557,455	56,782,296		1,272,833
1801	136,628,926	97,734,211	38,894,725		978,401
1802	98,630,775	61,180,288	37,450,487		689,446
1803	73,822,203	23,226,453	50,595,750		1,235,077
1804	128,722,669	74,172,220	54,550,449		1,573,714
1805	186,471,773	122,808,993	63,662,780		1,544,023
1806	199,133,437	145,630,841	53,502,596		1,396,316
1807	220,669,099	143,119,605	77,549,494	7,999,772	1,993,139
1808	104,411,777	28,962,527	75,459,250		1,763,008
1809	76,753,394	45,297,338	31,556,056		752,126
THIRD DECENNIUM.					
1810	55,104,722	47,024,002	8,080,720		410,452
1811	77,200,594	18,268,347	58,932,247		1,502,465
1812	83,409,956	13,927,277	69,482,679		1,765,403
1813	33,397,038	6,617,288	26,779,750		1,364,527
1814	29,464,943	762	29,464,181		1,503,279
1815	45,043,162	3,188,718	41,854,444	6,913,370	2,130,779
1816	55,110,381	17,723,967	37,386,414		1,911,861
1817	93,147,368	20,195,168	72,852,200		2,225,944
1818	68,358,936	22,057,904	46,301,032		1,415,565
1819	73,944,657	11,267,182	62,677,475		1,911,250
FOURTH DECENNIUM.					
1820	*b* 66,730,179	31,389,109	35,341,070		1,076,982
1821	59,515,701	20,061,725	39,453,976		1,202,360
1822	88,310,686	14,446,860	73,863,826		2,268,782
1823	60,791,470	21,459,024	39,332,446	1,779,881	1,189,907
1824	94,452,057	14,128,429	80,323,628	4,171,756	2,500,127
1825	71,772,468	21,836,771	49,935,697	2,617,965	1,507,043
1826	84,935,959	21,146,856	63,789,103	3,569,920	1,961,327
1827	76,702,280	15,343,530	61,358,750	3,385,958	1,872,943
1828	56,936,418	10,691,088	46,245,330	2,718,296	1,422,184
1829	63,308,621	12,343,478	50,965,143	2,807,599	1,559,174
FIFTH DECENNIUM.					
1830	86,490,113	9,725,342	76,764,771	3,946,547	2,352,155
1831	109,231,168	22,580,947	86,650,221	3,639,488	2,669,860
1832	66,488,891	17,536,028	48,952,863	2,001,303	1,498,399
1833	97,734,438	6,619,154	91,115,284	4,329,474	2,328,990
1834	115,392,096	13,969,203	101,422,893	4,703,312	2,575.155
1835	126,038,333	7,257,476	118,780.857	6,243,350	3,053,723
1836	191,428,305	34,492,282	156,938,023	9,681,940	3 948,104
1837	136,149,761	41,124,819	95,024,942	4,546,128	2,390,031
1838	153,883,863	11,624,324	142,259,539	6,697,656	3,617,377
1839	195,289,024	13,154,653	182,134.371	8,939,000	4,593,141

(*a*) These imports are for calendar years, and not fiscal years.
(*b*) Estimated by taking the mean between 1819 and 1821, there being no statistics of imports on record.
(*c*) The only reliable values on record, from 1790 to 1823, are those of 1807 and 1815, which are found in "Pitkin's Commerce of the United States."

I.

ghum Sugar, Candy, and Melado, in the U. S., for each fiscal year from 1790 *to* 1882.

Total.	Domestic.		Consumption.				Average Consumption, Per Capita.
	Produce.	Exports.	Foreign.	Domestic.	Total.	Population.	
Dollars.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Number.*	*Pounds.*
....	12,000,000	....	18,179,632	12,000,000	30,179,632	3,929,214	
....	13,000,000	....	24,825,978	13,000,000	37,825,978	4,049,247	
....	11,200,000	....	23,222,456	11,200,030	34,422,456	4,172,945	
....	14,215,000	....	43,150,517	14,215,000	57,365,517	4,300,425	
....	16,240,000	....	27,943,679	16,240,000	44,183,679	4,431,802	
....	13,290,000	....	41,583,263	13,290,000	54,873,263	4,567,292	9.65
....	15,340,000	....	23,719,239	15,340,000	39,059,239	4,706,926	
....	12,400,000	....	34,195,770	12,400,000	46,595,770	4,850,718	
....	14,499,500	....	26,936,602	14,499,500	41,436,102	4,998,706	
....	16,600,000	....	33,639,027	16,600,000	50,239,027	5,151,117	
....	16,000,000	....	56,146,185	16,000,000	72,146,185	5,308,483	
....	20,000,000	....	39,583,836	20,000,000	59,530,836	5,475,385	
....	21,000,000	....	30,245,045	21,000,000	51,245,015	5,647,854	
....	20,200,000	97,029	49,403,084	20,102,971	69,506,055	5,825,758	
....	22,499,500	924,181	62,948,587	21,575,319	84,523,906	6,009,469	
....	25,299,500	390,445	61,312,733	24,909,055	86,221,788	6,198,858	12.64
....	28,000,000	510,578	55,852,643	27,489,422	83,342,065	6,394,211	
9,992,911	28,000,000	139,986	77,549,494	27,860,014	105,409,508	6,595,718	
....	31,000,000	20,362	68,482,885	30,979,638	99,462,523	6,803,567	
....	34,000,000	287,921	30,085,070	33,712,079	63,797,149	7,018,007	
....	39,000,000	762,321	16,418,071	38,237,679	54,655,750	7,239,881	
....	38,603,070	244,242	58,932,247	38,358,828	97,291,075	7,449,832	
....	41,000,000	142,690	69,482,679	40,857,310	110,339,989	7,665,973	
....	42,500,000	732,320	26,779,750	41,767,680	68,547,430	7,888,280	
....	45,000,000	756	29,464,181	44,999,244	74,463,425	8,117,036	
9,044,149	43,000,000	16,692	41,854,444	42,983,308	84,837,752	8,352,429	10.86
....	46,000,000	79,577	37,386,414	45,920.423	83,306,837	8,595,645	
....	45,000,000	180,863	72,852,200	44,819,137	117,671,337	8,845,887	
....	47,500,000	111,894	46,301,032	47,388,106	93,689,138	9,103,354	
....	59,000,000	80,055	62,677,475	49,919,945	112,597,420	9,365,460	
....	51,000,000	80,836	35,341,070	50,919,164	86,260,234	9,638,453	
....	55,000,000	181,119	39,453,976	54,818,881	94,272,857	9,917,091	
....	58,000,000	185,658	73,863,826	57,814,342	131,678,168	10,205,555	
2,969,788	57,650,000	59,033	39,332,446	57,590,967	96,923,413	10,504,195	
6,671,883	63,960,000	63,868	80,323,628	63,896,132	144,219,760	10,813,777	
4,125,008	63,650,000	77,799	49,935,697	63,572,201	113,507,898	11,132,991	11.91
5,531,247	84,975,000	226,016	63,789,103	84,748,984	148,538,087	11,459,903	
5,258,901	117,005,000	255,447	61,358,750	116,749,553	178,108.303	11,803,775	
4,140,480	132,590,575	323,326	46,245,330	132,276,249	178,521,579	12,157,956	
4,366,773	90,014,890	532,996	50,965.143	89,481,894	140,447,037	12,508,898	
6,298,702	119,315,000	1,623,866	76,764,771	117,691,134	194,455,905	12,866,029	
6,309,348	123,625,000	2,237,619	86,650.221	121,387,381	208,037,602	13,205,429	
3,499,702	121,125,000	856,022	48,952,863	120,268,978	169,221,841	13,615,826	
6,658,464	116,850,000	517,076	91,115,284	116,332,924	207,448,208	14,019,343	
7,278,467	121,625,000	2,463,841	101,422,893	119,161,159	220,584,052	14,420,731	
9,297,073	152,500,000	870,506	118,780,857	151,629,494	270,410,351	14,814,243	15.40
13,630,044	72,150,000	1,571,108	156,936,023	70,578,892	227,514,915	15,270,483	
6,936,159	120,850,000	2,150,769	95,024,942	118,699,231	213,724,173	15,711,264	
10,315,033	113,075,000	3,019,451	142,259,539	110,055,549	252,315,088	16,120,891	
13,532,141	117,850,000	5,109,926	182,134,371	112,680,074	294,814,445	16,599,492	

TABLE

Years.	Foreign.			Value of Foreign Sugar Consumed.	
	Imports.	Exports.	Difference.	Value.	Paid for Customs.
SIXTH DECENNIUM.	*Pounds.*	*Pounds.*	*Pounds.*	*Dollars.*	*Dollars.*
1840	120,941,277	18,947,018	101,993,719	4,223,754	2,574,145
1841	184,264,995	11,814,266	172,450,715	7,950,808	4,385,295
1842	173,864,844	12,897,703	160,965,852	5,773,297	4,169,017
1843	*a* 71,339,050	1,886,976	69,444,470	2,439,402	1,795,020
1844	186,808,695	4,475,032	182,329,492	6,884,501	4,572,952
1845	115,666,656	13,799,637	101,865,203	4,063,202	2,573,331
1846	128,032,840	20,570,023	107,458,852	4,324,562	2,687,142
1847	236,970,894	8,394,918	228,573,926	9,406,444	3,165,490
1848	257,144,861	13,120,769	244,008,984	8,775,772	2,632,732
1849	259,326,584	17,149,994	242,169,247	7,276,241	2,182,872
SEVENTH DECENNIUM.					
1850	218,439,055	14,153,065	204,272,283	6,953,667	2,086,099
1851	380,423,569	6,387,108	374,014,916	13,483,178	4,014,954
1852	457,544,544	9,573,357	447,937,734	13,924,707	4,177,410
1853	464,427,281	18,981,701	445,418,963	13,934,467	4,180,341
1854	455,964,452	52,019,584	403,894,136	12,467,108	3,440,133
1855	473,884,218	33,716,323	440,114,752	13,323,505	3,997,052
1856	545,262,754	23,341,474	521,872,706	21,373,859	6,412,158
1857	777,003,115	14,731,801	762,137,041	41,731,898	12,519,569
1858	519,240,945	74,910,624	444,330,321	19,083,918	4,580,140
1859	655,868,415	33,608,653	622,003,778	28,670,426	5,880,902
EIGHTH DECENNIUM.					
1860	694,879,795	34,016,070	660,777,373	29,291,087	7,029,861
1861	809,813,489	80,408,714	729,404,775	27,254,957	10,011,932
1862	557,143,184	23,552,145	533,591,039	19,049,781	10,724,725
1863	522,131,247	16,155,557	502,448,466	17,642,237	10,272,961
1864	632,248,612	27,271,713	605,949,979	27,069,139	12,317,647
1865	651,971,882	30,743,484	614,067,543	23,696,358	18,972,632
1866	1,000,076,709	8,580,092	991,496,617	40,182,049	30,633,113
1867	849,108,911	12,210,707	835,416,841	*b* 38,513,055	*b* 28,589,781
1868	1,121,221,670	16,112,818	1,105,108,852	43,434,090	30,455,442
1869	1,247,885,371	17,828,678	1,230,056,693	48,258,660	30,929,337
NINTH DECENNIUM.					
1870	1,196,829,389	18,383,902	1,178,495,487	60,270,688	36,829,037
1871	1,277,525,009	10,364,161	1,267,160,848	60,849,370	30,758,657
1872	1,509,249,507	12,122,280	1,497,127,227	76,029,865	28,876,131
1873	1,568,393,877	23,930,453	1,544,463,424	79,513,278	29,842,942
1874	1,701,354,312	19,310,777	1,682,043,535	81,491,851	32,499,835
1875	1,797,586,806	11,200,857	1,786,385,949	71,800,598	34,662,057
1876	1,494,065,427	15,870,600	1,478,194,827	67,030,351	39,450,917
1877	1,623,973,537	3,122,956	1,620,850,581	73,780,829	35,274,468
1878	1,507,120,551	6,016,855	1,501,103,696	82,659,480	37,080,803
1879	1,834,403,349	10,389,906	1,824,013,443	69,964,566	38,074,137
TENTH DECENNIUM.					
1880	1,829,355,368	10,501,791	1,818,853,577	72,197,267	39,804,805
1881	1,946,804,201	9,728,295	1,937,075,906	88,372,629	46,325,011
1882	1,990,234,525	5,625,199	1,984,609,326	91,752,195	46,994,644

(*a*) These statistics are from October 1st, 1842, to June 30th, 1843, nine months.
(*b*) The "Values," "Paid for Customs," and foreign sugar consumed, are quoted from the consumption tables in the Annual Reports of the Bureau of Statistics.

I.—*Continued.*

Total.	Domestic.		Consumption.				Average Consumption, Per Capita.
	Produce.	Exports.	Foreign.	Domestic.	Total.	Population.	
Dollars.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Number.*	*Pounds.*
6,797,899	167,930,705	11,511,556	101,993,719	156,419,149	258,412,868	17,070,240	
12,336,103	135,442,000	13,747,948	172,450,615	121,694,052	294,144,667	17,563,990	
9,942,314	142,277,795	3,596,879	160,965,852	138,680,916	299,646,768	18,065,813	
4,234,422	200,240,000	667,447	69,444,470	199,572,553	269,017,023	18,603,956	
11,457,453	137,003,436	1,858,225	182,329,492	135,145,211	317,474,703	19,102,946	
6,636,533	273,979,000	2,193,977	101,865,203	271,785,023	373,650,226	19,640,029	18.73
7,011,704	235,371,625	4,237,807	107,458,852	231,133,818	338,592,670	20,225,760	
12,571,934	192,002,000	1,927,472	228,573,926	190,074,528	418,648,454	20,869,760	
11,408,504	312,510,570	3,513,779	244,008,984	308,996,791	553,005,775	21,609,554	
9,459,113	292,772,000	2,356,104	242,169,247	290,415,896	532,585,143	22,358,293	
9,039,766	328,785,960	3,244,861	204,272,283	325,541,099	529,813,382	23,191,876	
17,528,132	283,048,788	3,251,369	374,014,916	270,797,419	653,812,335	23,974,993	
18,102,117	310,517,836	2,498,390	447,937,734	308,019,446	755,957,180	24,843,547	
18,114,808	409,457,592	5,827,331	445,418,963	403,630,261	849,049,224	25,721,956	
15,907,241	549,283,584	9,893,751	403,894,136	539,389,833	943,283,969	26,615,328	30.18
17,320,557	426,387,582	11,160,945	440,114,752	415,226,637	855,341,389	27,586,113	
27,786,017	295,843,882	9,271,191	521,872,706	286,572,691	808,445,397	28,349,746	
54,251,467	114,405,480	5,338,247	762,137,041	109,067,233	871,204,274	29,124,515	
23,664,058	366,540,144	7,201,090	444,330,321	359,339,054	803,669,375	29,966,042	
35,551,328	465,972,150	6,558,757	622,003,778	459,413,393	1,081,417,171	30,685,586	
36,320,948	302,209,105	4,466,031	660,777,673	297,743,074	958,520,447	31,443,321	
37,266,889	312,294,955	6,511,134	729,404,775	305,783,821	1,035,188,596	32,238,403	
29,774,506	595,980,722	2,755,252	533,591,039	593,225,470	1,126,816,509	32,987,985	
27,915,198	281,923,795	3,595,009	502,448,466	278,328,786	780,777,252	38,211,430	
39,386,786	128,568,644	2,328,483	605,949,979	126,240,161	732,190,140	33,345,224	28.16
42,668,990	51,903,854	2,132,147	614,067,543	49,771,707	663,839,250	33,394,882	
70,820,142	58,715,645	4,460,138	991,496,617	54,255,507	1,045,752,124	34,324,665	
67,102,836	82,698,658	8,197,550	*a* 939,806,458	74,501,108	1,014,307,566	35,342,849	
73,889,532	76,689,844	2,282,655	1,000,886,403	74,407,189	1,075,293,593	36,361,669	
79,187,997	129,142,286	3,187,993	1,018,807,068	125,954,298	1,144,761,361	37,400,130	
97,099,725	132,979,178	4,501,221	1,216,459,872	128,477,957	1,344,937,829	38,558,371	
91,608,027	208,196,046	3,945,923	1,231,883,061	204,250,123	1,436,133,184	39,723,755	
104,905,996	186,106,426	4,590,932	1,412,919,438	181,515,494	1,594,434,932	40,967,095	
109,356,220	163,955,047	10,222,728	1,485,657,191	153,732,319	1,639,389,510	42,265,762	
113,991,686	141,629,424	15,685,587	1,644,765,505	126,043,837	1,770,809,342	43,456,931	38.28
106,462,655	184,536,695	35,694,888	1,649,100,179	148,841,807	1,797,941,986	44,588,083	
106,481,268	214,974,473	52,024,916	1,658,719,324	162,949,557	1,821,668,881	45,687,668	
109,055,297	241,286,958	54,073,314	1,505,086,114	187,213,644	1,692,299,758	46,761,551	
119,740,283	155,928,057	44,093,092	1,620,087,542	111,834,965	1,731,922,507	47,874,485	
108,038,703	253,847,478	72,352,964	1,681,349,585	181,494,514	1,862,844,099	....	
112,002,072	210,900,015	30,142,004	1,687,576,123	180,758,011	1,868,334,134	50,155,783	....
134,697,640	289,361,873	22,252,833	1,966,669,984	267,109,040	2,233,779,024	....	....
137,746,839	169,467,447	13,814,005	2,033,787,066	155,653,442	2,189,440,508	....	....

(*a*) See note (*b*), page 32.

TABLE

Imports, Exports, Cost, Production, and Consumption of Cane Mo-

Years.	Foreign.			Value of cane molasses consumed.	
	Imports.	Exports.	Difference.	Value.	Paid for customs.
FIRST DECENNIUM.	*Gallons.*	*Gallons.*	*Gallons.*	*Dollars.*	*Dollars.*
1790	5,992,646	15,537	5,977,109	....	149,428
1791	7,194,606	12,721	7,181.885	1,429,195	215,457
1792	*a* 5.229,915	11,338	5,218,577	....	156,557
1793	*a* 4,930,141	28,733	4,901,408	....	147,042
1794	*a* 3,476,906	7,216	3,469,690	....	104,091
1795	4,425,621	20,124	4,405,497	....	132,165
1796	4,965,191	112,257	1,852,934	....	145,588
1797	3,876,420	48,559	3,827,861	....	153,114
1798	4,629,370	32,350	4,597,020	....	183,881
1799	4,100,242	61,911	4,038,331	....	161,533
SECOND DECENNIUM.					
1800	4,092,677	39,122	4,053,555	....	162,142
1801	5,717,290	421,628	5,295,662	....	211,826
1802	6,833,261	56,959	6,776,302	2,026,114	271,052
1803	6,725,400	38,552	6,683,848	1,992,681	267,474
1804	5,747,256	55,259	5,691,997	1,702,907	227,680
1805	9,021,700	48,474	8,973,226	....	448,661
1806	8,597,456	53,798	8,543,658	....	427,183
1807	8,511,234	40,957	8,470,277	3,125,532	423,514
1808	6,489,008	7,337	6,481,671	....	324,084
1809	5,219,415	33,943	5,185,472	....	259,274
THIRD DECENNIUM.					
1810	8,055,629	40,245	8,015,384	....	400,769
1811	8,634,418	18,837	8,615,581	....	430,779
1812	8,141,264	8,001	8,133,263	....	406,663
1813	3,199,361	1,309	3,198,052	....	319,805
1814	3,376,367	....	3,376,367	....	337,637
1815	4,752,642	11,228	4,771,414	....	474,141
1816	8,494,248	29,008	8,465,240	....	846,524
1817	11,480,948	14,457	11,466,491	....	573,325
1818	12,353,985	11,478	12,342,507	....	617,125
1819	10,583,298	20,486	10,562,812	....	528,141
FOURTH DECENNIUM.					
1820	*b* 9,835.140	82,571	9,752,569	....	487,628
1821	9,086,982	39,421	9,047,561	1,707,995	452,378
1822	11,990,569	13,292	11,977,277	2,393,945	598,864
1823	13,019,328	3,409	13.015,919	2,633,228	650,796
1824	13,117,724	18,737	13,098,987	2,408,911	654,949
1825	12,535,062	15,806	12,519,256	2,543,137	625,963
1826	13,843,045	50,602	13,792,443	2,822,309	689,622
1827	13,376,502	20,107	13,356,395	2,812,490	667,820
1828	13,393.651	30,168	13,363,483	2,778,983	668,174
1829	10,150,224	36,920	10,113,304	1,475,609	1,011,330
FIFTH DECENNIUM.					
1830	8,374,139	27,121	8,347,018	988,985	834,702
1831	17,085,878	17,695	17,068,183	2,427,708	853,409
1832	15,860,553	29,656	15,830,897	2,515,498	791,545
1833	15,693,050	18,730	15,674,320	2,862,536	783,716
1834	17,086,472	58.736	17,027,736	2,975,223	851,387
1835	18,971,603	50,776	18,920,827	3,062,045	946,041
1836	18,051,784	42,951	18,008,833	4,061,240	900,442
1837	16,451,182	90,597	16,360,585	3,411,757	818,029
1838	21,196,411	62,098	21,134,313	3,845,701	1,056,716
1839	23,094,677	121,171	22,973,506	4,327,500	1,148,675

(*a*) These imports are for calendar years, and not fiscal years.
(*b*) Estimated by taking the mean between 1819 and 1821, there being no imports on record for this year.

II.

lasses in the United States for each fiscal year from 1790 *to* 1882.

Total.	Domestic.		Consumption.				Average Consumption Per Capita.
	Produce.	Exports.	Foreign.	Domestic.	Total.	Population.	
Dollars.	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Number.*	*Gallons.*
....	....	....	5,977,109	....	5,977,109	3,929,214	
1,644,651	....	....	7,181,885	....	7,181,885	4,049,247	
....	18,181	....	5,218,567	18,181	5,236,758	4,172,945	
....	19,545	....	4,901,408	19,545	4,920,953	4,300,425	
....	21,818	....	3,469,690	21,818	3,491,508	4,431,802	
....	26,363	....	4,405,497	26,363	4,431,860	4,567,292	1.07
....	30,909	....	4,852,934	30,909	4,883,843	4,706,926	
....	36,363	....	3,827,861	36,363	3,864,224	4,850,718	
....	45,409	....	4,597,020	45,409	4,642,429	4,998,706	
....	54,545	....	4,038,331	54,545	4,092,876	5,151,117	
....	90,909	....	4,053,555	90,909	4,144,464	5,308,483	
....	272,727	....	5,295,662	272,727	5,568,389	5,475,385	
2,297,166	454,545	....	6,776,302	454,545	7,230,847	5,647,854	
2,260,154	563,636	....	6,686,848	563,636	7,250,484	5,825,758	
1,930,586	681,772	....	5,691,997	681,772	6,373,769	6,009,469	
....	754,500	....	8,973,226	754,500	9,727,726	6,198,858	1.19
....	818,181	....	8,543,658	818,181	9,361,839	6,394,211	
3,549,046	909,090	....	8,470,277	909,090	9,379,367	6,595,718	
....	1,272,727	....	6,481,671	1,272,727	7,754,398	6,803,567	
....	1,363,636	....	5,185,472	1,363,636	6,549,108	7,018,007	
....	1,333,333	....	8,015,384	1,333,333	9,348,717	7,239,881	
....	1,500,000	....	8,615,581	1,500,000	10,115,581	7,449,832	
....	1,583,333	....	8,133,263	1,583,333	9,716,596	7,665,973	
....	1,666,666	....	3,198,052	1,666,666	4,864,718	7,888,280	
....	1,750,000	....	3,376,367	1,750,000	5,126,367	8,117,036	
....	1,833,333	....	4,741,414	1,833,333	6,574,747	8,352,429	1.16
....	1,916,666	....	8,465,240	1,916,666	10,381,906	8,595,645	
....	2,000,000	....	11,466,491	2,000,000	13,466,491	8,845,887	
....	2,041,666	....	12,342,507	2,041,666	14,384,173	9,103,354	
....	2,093,333	....	10,562,812	2,093,333	12,656,145	9,365,460	
....	2,250,000	....	9,752,569	2,250,000	12,002,569	9,638,453	
2,160,373	2,416,666	....	9,047,561	2,416,666	11,464,227	9,917,091	
2,992,809	2,500,000	....	11,977,277	2,500,000	14,477,277	10,295,555	
3,284,024	2,887,500	....	13,015,919	2,887,500	15,903,419	10,504,195	
3,063,860	3,080,000	....	13,098,987	3,080,000	16,178,987	10,813,777	
3,169,100	2,887,500	....	12,519,256	2,887,500	15,406,756	11,132,991	1.45
3,511,931	4,331,250	*a* 2,070	13,792,443	4,329,180	18,121,623	11,459,903	
3,480,309	6,833,750	5,037	13,356,395	6,828,713	20,185,108	11,803,775	
3,447,157	8,466,631	2,003	13,363,483	8,464,628	21,828,111	12,157,956	
2,486,939	4,642,907	6,640	10,113,304	4,636,267	14,749,571	12,508,898	
1,823,687	6,485,769	13,227	8,347,018	6,472,542	14,819,560	12,866,020	
3,281,117	6,663,461	3,160	17,068,183	6,660,301	23,728,484	13,205,429	
3,307,043	6,663,461	8,310	15,830,897	6,655,151	22,486,048	13,615,826	
3,646,252	6,219,230	7,597	15,674,320	6,211,633	21,885,953	14,019,343	
3,826,610	6,663,461	19,780	17,027,736	6,643,681	23,671,417	14,420,731	
4,008,086	8,884,615	6,543	18,920,827	8,878,072	27,798,899	14,814,243	1.59
4,961,682	2,665,384	2,837	18,008,833	2,662,547	20,761,380	15,270,483	
4,229,786	6,219,230	23,903	16,360,585	6,195,327	22,555,912	15,711,264	
4,902,417	5,775,000	22,067	21,134,313	5,752,933	26,887,246	16,120,891	
5,476,175	6,219,230	11,460	22,973,506	6,207,770	29,181,276	16,599,492	

(*a*) From 1826 to 1835, inclusive, the statistics of domestic exports are given in value, which are reduced at the rate of 30 cents per gallon.

TABLE

Years.	Foreign.			Value of cane molasses consumed.	
	Imports.	Exports.	Difference.	Value.	Paid for customs.
SIXTH DECENNIUM.	*Gallons.*	*Gallons.*	*Gallons.*	*Dollars.*	*Dollars.*
1840	19,703,620	188,078	19,515,542	2,861,261	975,777
1841	19,355,028	328,786	19,026,242	2,542,933	951,312
1842	17,834,927	203,472	17,631,455	1,908,131	881,573
1843	*a* 11,776,047	100,763	11,675,284	1,116,310	525,388
1844	22,675,352	224,668	22,450,684	2,795,555	1,010,281
1845	18,301,033	297,949	18,003,084	3,072,021	810,139
1846	22,760,622	414,678	22,345,944	3,254,075	1,005,567
1847	30,677,630	1,467,418	29,210,212	2,740,392	872,494
1848	33,640,287	559,735	33,080,552	3,337,865	1,001,360
1849	23,796,806	793,535	23,003,271	2,636,920	791,076
SEVENTH DECENNIUM.					
1850	25,044,835	581,820	24,463,015	2,785,117	835,535
1851	36,376,772	226,592	36,150,180	3,663,323	1,098,997
1852	32,795,610	325,958	32,469,652	3,534,277	1,060,283
1853	31,886,100	488,666	31,397,434	3,587,008	1,076,102
1854	27,759,463	889,295	26,870,168	2,946,562	883,969
1855	26,385,593	1,517,474	24,868,119	3,190,706	957,212
1856	23,617,674	1,261,140	22,356,534	4,028,488	1,208,546
1857	32,705,844	1,441,660	31,264,184	7,748,961	2,324,688
1858	24,566,357	3,908,075	20,658,282	2,991,326	717,918
1859	32,818,146	2,113,669	30,704,477	4,543,012	1,090,323
EIGHTH DECENNIUM.					
1860	30,922,633	1,222,118	29,700,515	4,932,886	1,183,893
1861	29,941,397	3,068,986	26,872,411	3,508,330	709,862
1862	25,157,280	1,296,564	23,860,716	3,213,983	1,193,036
1863	30,854,264	1,156,799	29,697,465	4,439,597	1,781,848
1864	33,571,230	953,472	32,617,758	7,005,603	2,609,421
1865	37,306,168	1,487,815	35,818,353	6,965,428	2,865,468
1866	45,285,983	1,020,544	44,265,439	7,495,864	3,541,235
1867	56,123,079	639,888	55,483,191	*b* 8,916,311	*b* 4,009,321
1868	56,408,435	548,428	55,860,007	11,884,702	4,402,624
1869	53,304,030	2,315,842	50,988,188	11,847,827	4,168,900
NINTH DECENNIUM.					
1870	56,373,537	1,606,272	54,767,265	11,345,631	3,821,461
1871	44,401,359	1,002,184	43,399,175	10,953,029	3,826,462
1872	45,214,403	310,588	44,903,815	10,108,889	2,102,896
1873	43,533,909	558,289	42,975,620	10,424,652	2,205,621
1874	47,189,837	958,280	46,231,557	11,122,174	2,360,282
1875	49,112,255	648,488	48,463,767	10,409,255	2,495,189
1876	39,026,200	1,058,815	37,967,385	8,712,116	2,447,658
1877	30,188,963	302,891	29,886,072	7,335,194	1,812,525
1878	27,490,007	844,206	26,645,801	6,874,767	1,678,485
1879	38,460,347	734,706	37,725,641	6,914,983	2,209,660
TENTH DECENNIUM.					
1880	38,120,880	77,878	38,043,002	8,997,844	2,465,265
1881	28,708,221	616,831	28,091,390	6,401,214	1,659,064
1882	37,268,830	172,773	37,096,057	9,714,943	2,221,692

(*a*) These statistics are from October 1st, 1842, to June 30th, 1843—nine months.
(*b*) The *values* and *amounts* paid for customs after 1866 were calculated on the amount entered for consumption.

II—*Continued.*

Total.	Domestic.		Consumption.				Average Consumption Per Capita.
	Produce.	Exports.	Foreign.	Domestic.	Total.	Population.	
Dollars.	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Number.*	*Gallons.*
3,836,936	10,217,307	32,583	19,515,542	10,184,724	29,700,266	17,070,240	
3,494,245	7,803,230	26,663	19,026,242	7,776,567	26,802,809	17,563,990	
2,789,704	8,072,317	63,467	17,631,455	8,008,850	25,640,305	18,065,813	
1,641,698	12,556,923	4,390	11,675,284	12,552,533	24,227,817	18,603,956	
3,805,836	9,000,264	13,073	22,450,684	8,987,191	31,437,875	19,102,946	
3,882,160	17,923,076	69,237	18,003,084	17,853,839	35,856,923	19,640,029	1.80
4,259,642	16,682,769	5,270	22,345,944	16,677,499	39,023,443	20,225,760	
3,612,886	12,556,923	89,863	29,210,212	12,467,060	41,677,272	20,869,760	
4,339,225	21,526,153	18,543	33,080,552	21,507,610	54,588,162	21,609,554	
3,427,996	19,938,461	24,807	23,003,271	19,913,654	42,916,925	22,358,293	
3,620,652	21,038,037	47,123	24,463,015	20,990,914	45,453,929	23,191,876	
4,762,320	17,921,913	56,100	36,150,180	17,865,813	54,015,993	23,974,993	
4,594,560	20,072,702	43,877	32,469,652	20,028,825	52,498,477	24,843,547	
4,663,110	27,318,399	58,607	31,397,434	27,259,792	58,657,226	25,721,956	
3,830,531	37,422,270	436,413	26,870,168	36,985,857	63,856,025	26,615,328	
4,147,918	28,869,743	790,956	24,868,119	28,078,787	52,946,906	27,586,113	1.89
5,237,034	19,274,563	454,315	22,356,534	18,820,248	41,176,782	28,349,746	
10,073,649	6,243,248	207,931	31,264,184	6,035,317	37,299,501	29,124,515	
3,709,244	23,824,189	290,046	20,658,282	23,534,143	44,192,425	29,966,042	
5,633,335	30,568,725	181,341	30,704,477	30,387,384	61,091,861	30,685,586	
6,116,779	18,717,750	79,439	29,700,515	18,638,311	48,338,826	31,443,321	
4,218,192	19,301,032	91,593	26,872,411	19,209,439	46,081,850	32,238,403	
4,407,019	39,417,378	45,009	23,860,716	39,372,369	63,233,085	32,987,985	
6,221,445	17,160,000	39,290	29,697,465	17,120,710	46,818,175	33,211,430	
9,615,024	6,275,738	47,455	32,617,758	6,228,283	38,846,041	33,345,224	
9,830,896	848,766	30,875	35,818,353	817,891	36,636,244	33,394,882	1.45
11,037,099	1,476,577	55,653	44,265,439	1,420,924	45,686,363	34,324,665	
12,925,632	3,350,285	59,544	*a* 50,116,517	3,290,741	53,407,258	35,342,849	
16,287,326	3,076,297	42,543	55,006,060	3,033,754	58,039,814	36,361,669	
16,016,727	7,128,841	268,995	52,111,252	6,859,846	58,971,098	37,400,130	
15,167,092	6,961,706	299,672	47,768,267	6,662,034	54,430,301	38,558,371	
13,779,491	11,821,501	2,946,113	47,260,021	8,875,398	56,135,419	39.723,755	
12,211,785	10,283,428	2,726,858	42,057,924	7,556,570	49,614,494	40,967 095	
12,630,273	8,774,254	3,055,836	44,112,413	5,718,418	49,830,831	42,265,762	
13,482,456	7,226,878	2,447,905	47,205,641	4,778,973	51,984,614	43,456,931	
12,904,444	9,415,328	4,769,292	43,220,697	4,646,036	47,866,733	44,588,083	1.15
11,159,774	11,439,264	4,408,412	39,213,805	7,030,852	46,244,657	45,687,668	
9,147,719	13,347,079	3,470,827	29,000,397	9,876,252	38,876,649	46,761,551	
8,553,252	20,359,310	1,477,057	26,943,298	18,882,253	45,825,551	47,874,485	
9,124,643	18,902,318	4,727,367	35,353,586	14,174,951	49,528,537	....	
11,463,109	17,430,452	3,596,010	39,545,695	13,834,532	53,380,227	....	....
8,060,278	21,814,691	2,214,467	26,744,013	19,600,224	46,344,237	....	....
11,936,635	13,858,279	1,892,050	35,696,353	11,966,229	47,662,582	....	....

(*a*) After 1867, inclusive, the amounts of foreign molasses consumed were obtained from the Annual Reports on "Commerce and Navigation," and not by subtracting the exports from the imports, as was done previous to that date.

TABLE III.—*Production, exports, and consumption of molasses in the United States for each fiscal year, from 1790 to 1882.*

Years.	Domestic molasses.					Aggregate of all kinds of molasses.				Aver'ge consumption per capita.
	Sorghum.	Maple.	Cane.			Consumption.				
	Produce.	Produce.	Produce.	Exports.	Consumed	Foreign.	Domestic.	Total.	Population	
FIRST DECENNIUM.	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Number.*	*Galls.*
1790	...	a200,000	...	...	...	5,977,109	200,000	6,177,109	3,929,214	1.12
1791	...	216,000	...	...	...	7,181,885	216,000	7,397,885	4,049,247	
1792	...	183,300	b18,181	...	18,181	5,218,577	201,481	5,420,058	4,172,945	
1793	...	233,300	19,545	...	19,545	4,901,408	252,845	5,154,253	4,300,425	
1794	...	266,600	21,818	...	21,818	3,469,690	288,418	3,758,108	4,431,802	
1795	...	216,600	26,363	...	26,363	4,405,497	242,963	4,648,460	4,567,292	
1796	...	250,000	30,909	...	30,909	4,852,934	280,909	5,133,843	4,706,926	
1797	...	200,000	36,363	...	36,363	3,827,861	236,363	4,064,224	4,850,718	
1798	...	233,300	45,409	...	45,409	4,597,020	278,709	4,875,729	4,998,706	
1799	...	251,600	54,545	...	54,545	4,038,331	306,145	4,344,476	5,151,117	
SECOND DECENNIUM.										
1800	...	250,000	90,909	...	90,909	4,053,555	340,909	4,394,464	5,308,483	1.20
1801	...	283,300	272,727	...	272,727	3,295,662	556,027	3,851,689	5,475,385	
1802	...	266,600	454,545	...	454,545	6,776,302	721,145	7,497,447	5,647,854	
1803	...	233,300	363,636	...	363,636	6,686,848	596,936	7,283,784	5,825,758	
1804	...	250,000	681,772	...	681,772	5,691,997	931,772	6,623,769	6,009,469	
1805	...	283,300	754,500	...	754,500	8,973,226	1,037,800	10,011,026	6,108,858	
1806	...	316,600	818,181	...	818,181	8,543,658	1,134,781	9,678,439	6,394,211	
1807	...	300,000	909,090	...	909,090	8,470,277	1,209,090	9,679,367	6,595,718	
1808	...	283,300	1,272,727	...	1,272,727	6,481,671	1,556,027	8,037,698	6,803,567	
1809	...	316,600	1,363,636	...	1,363,636	5,185,472	1,680,236	6,865,708	7,018,007	
THIRD DECENNIUM.										
1810	...	383,300	1,333,333	...	1,333,333	8,015,384	1,716,633	9,731,017	7,239,881	1.21
1811	...	343,384	1,500,000	...	1,500,000	8,615,581	1,843,384	10,458,965	7,449,832	
1812	...	366,600	1,583,333	...	1,583,333	8,133,263	1,949,933	10,083,196	7,665,973	
1813	...	375,500	1,666,666	...	1,666,666	3,198,052	2,042,166	5,240,218	7,888,280	
1814	...	400,000	1,750,000	...	1,750,000	3,376,367	2,150,000	5,526,367	8,117,036	
1815	...	350,000	1,833,333	...	1,833,333	4,741,414	2,183,333	6,924,747	8,352,429	
1816	...	383,800	1,916,666	...	1,916,666	8,465,240	2,300,466	10,765,706	8,595,645	
1817	...	350,000	2,000,000	...	2,000,000	11,466,491	2,350,000	13,816,491	8,845,887	
1818	...	383,300	2,041,666	...	2,041,666	12,342,507	2,424,966	14,767,473	9,103,354	
1819	...	416,600	2,093,333	...	2,099,333	10,562,812	2,509,933	13,072,745	9,365,460	

a The product of maple molasses has been determined from the maple-sugar product. See table for maple-sugar.
b The product of cane molasses has been determined from the sugar crop of Louisiana from 1823, and by making suitable additions for the crop outside of that State. Previous to that date, it has been obtained from the estimated sugar crop. See cane sugar table.

TABLE III.—*Production, exports, and consumption of molasses in the United States for each fiscal year, from 1790 to 1882.—Continued.*

FOURTH DECENNIUM.	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Number.*	*Galls.*
1820	....	400,000	2,250,000	....	2,250,000	9,752,569	2,650,000	12,402,569	9,638,453	
1821	....	433,000	2,416,666	....	2,416,666	9,047,561	2,849,666	11,897,227	9,917,091	
1822	....	466,600	2,500,000	....	2,500,000	11,977,277	2,966,600	14,943,877	10,205,555	
1823	....	383,300	2,887,500	....	2,887,500	13,015,919	3,270,800	16,286,719	10,504,195	
1824	....	450,000	3,080,000	....	3,080,000	13,098,987	3,530,000	16,628,987	10,813,777	1.49
1825	....	483,300	2,887,500	....	2,887,500	12,519,256	3,370,800	15,890,056	11,132,191	
1826	....	550,000	4,331,250	2,070	4,329,180	13,792,443	4,879,180	18,671,623	11,459,903	
1827	....	581,300	6,833,750	5,037	6,828,713	13,356,395	7,410,013	20,766,408	11,803,775	
1828	....	516,600	8,466,631	2,003	8,464,028	13,363,483	8,981,228	22,344,711	12,157,956	
1829	....	571,600	4,642,907	6,640	4,636,267	10,113,304	5,207,867	15,321,171	12,508,898	
FIFTH DECENNIUM.										
1830	....	583,000	6,485,769	13,227	6,472,542	8,347,018	7,055,542	15,402,560	12,866,020	
1831	....	616,000	6,663,461	3,160	6,660,301	17,068,183	7,276,301	24,344,484	13,205,429	
1832	....	575,000	6,663,461	8,310	6,655,151	15,830,897	7,230,151	23,061,048	13,615,826	
1833	....	600,000	6,219,230	7,597	6,211,633	15,674,320	6,811,633	22,485,953	14,019,343	
1834	....	583,000	6,663,461	19,780	6,643,681	17,027,736	7,226,681	24,254,417	14,420,731	1.63
1835	....	616,000	8,884,615	6,543	8,878,072	18,920,827	9,494,072	28,414,899	14,814,243	
1836	....	625,000	2,665,384	2,837	2,662,547	18,008,833	3,287,547	21,296,380	15,270,483	
1837	....	666,000	6,219,230	23,903	6,195,327	16,360,585	6,861,327	23,221,912	15,711,264	
1838	....	633,000	5,775,000	22,067	5,752,933	21,134,313	6,385,933	27,520,246	16,120,891	
1839	....	616,000	6,219,230	11,460	6,207,770	22,973,506	6,823,770	29,797,276	16,599,492	
SIXTH DECENNIUM.										
1840	....	671,920	10,217,307	32,583	10,184,724	19,515,542	10,856,644	30,372,186	17,070,240	
1841	....	625,000	7,803,230	26,663	7,776,567	19,026,242	8,401,567	27,427,809	17,563,990	
1842	....	650,000	8,072,317	63,467	8,008,850	17,631,455	8,658,850	26,290,305	18,065,813	
1843	....	690,000	12,556,923	4,390	12,552,533	11,675,284	13,242,533	24,917,817	18,603,956	
1844	....	325,000	9,000,264	13,073	8,987,191	22,450,684	9,312,191	31,762,875	19,102,946	
1845	....	738,000	17,923,076	69,237	17,853,839	18,003,084	18,591,839	36,594,923	19,640,029	1.83
1846	....	420,000	16,682,769	5,270	16,677,499	22,345,944	17,097,499	39,443,443	20,225,760	
1847	....	470,000	12,556,923	89,863	12,467,060	29,210,212	12,937,060	42,147,272	20,869,760	
1848	....	580,000	21,526,153	18,543	21,507,610	33,080,552	22,087,610	55,168,162	21,609,554	
1849	....	598,000	19,938,461	24,807	19,913,654	23,003,271	20,511,654	43,514,925	22,358,293	
SEVENTH DECENNIUM.										
1850	....	632,965	21,038,037	47,123	20,990,914	24,463,015	21,623,879	46,086,894	23,191,876	
1851	....	641,000	17,921,913	56,100	17,865,813	36,150,180	18,406,813	54,956,993	23,974,993	
1852	....	670,000	20,072,702	43,877	20,028,825	32,469,652	20,698,825	53,168,477	24,843,547	
1853	....	650,000	27,318,399	58,607	27,259,792	31,397,434	27,909,792	59,307,226	25,721,956	
1854	....	1,107,000	37,422,270	436,413	36,985,857	26,870,168	38,092,857	64,963,025	26,615,328	1.95
1855	....	936,012	28,869,743	790,956	28,078,787	24,868,119	29,014,799	53,882,918	27,586,113	
1856	....	897,000	19,274,563	454,315	18,820,248	22,356,534	19,717,248	42,073,782	28,349,746	
1857	a1,645	900,000	6,243,248	207,931	6,035,317	31,264,184	6,936,962	38,201,146	29,124,515	
1858	542,000	1,100,000	23,824,189	290,046	23,534,143	20,658,282	25,176,143	45,834,425	29,966,042	
1859	6,747,123	1,275,000	30,568,725	181,341	30,387,384	30,704,477	38,409,507	69,113,984	30,685,586	

(a) The product of sorghum molasses, has been determined by the returns of the census of the United States and those of the several States for certain years. The intervening years have been estimated.

TABLE III.—*Production, export, and consumption of molasses in the United States for each fiscal year, from* 1790 *to* 1882.—*Continued.*

Years.	Domestic molasses.					Aggregate of all kinds of molasses.				Average consumption per capita.
	Sorghum.	Maple.	Cane.			Consumption.				
	Produce.	Produce.	Produce.	Exports.	Consumed	Foreign.	Domestic.	Total.	Population	
EIGHTH DECENNIUM.	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Number.*	*Galls.*
1860	7,176,042	1,597,589	18,717,750	79,439	18,638,311	29,700,515	27,411,942	57,112,457	31,443,321	1 98
1861	10,476,000	1,600,000	19,301,032	91,593	19,209,439	26,872,411	31,285,439	58,157,850	32,238,403	
1862	14,352,084	1,750,000	34,417,738	45,009	39,372,369	23,860,716	55,474,453	79,335,169	32,987,985	
1863	17,940,105	1,550,000	17,160,000	39,290	17,120,710	29,697,465	36,610,815	66,308,280	33,211,430	
1864	16,500,000	1,500,000	6,275,738	47,455	6,228,283	32,617,758	24,228,283	56,846,041	33,345,224	
1865	19,000,000	1,534,467	848,766	30,875	817,891	35,818,353	21,352,358	57,170,711	33,394,882	
1866	21,560,000	1,341,000	1,476,577	65,653	1,420,924	44,265,439	24,261,924	68,527,363	34,324,665	
1867	20,000,000	1,266,000	3,350,285	59,544	3,290,741	50,116,517	24,556,741	74,673,258	35,342,849	
1868	18,500,000	1,153,000	3,076,297	42,543	3,033,754	55,006,060	22,686,754	77,692,814	36,361,669	
1869	16,050,089	934,000	7,128,841	268,995	6,859,846	52,111,252	23,843,935	75,955,187	37,400,130	
NINTH DECENNIUM.										
1870	18,750,000	921,057	6,961,706	299,672	6,662,034	47,768,267	26,333,091	74,101,358	38,558,371	1 55
1871	17,000,000	1,421,000	11,821,501	2,946,113	8,875,398	47,260,021	27,296,398	74,556,419	39,723,755	
1872	16,000,000	1,547,000	10,283,428	2,726,858	7,556,570	42,057,924	25,103,570	67,161,494	40,967,095	
1873	15,000,000	1,632,000	8,774,254	3,055,836	5,718,418	44,112,413	23,350,418	66,462,831	42,265,762	
1874	16,000,000	1,678,920	7,226,876	2,447,905	4,778,973	47,205,641	22,457,893	69,663,534	43,456,931	
1875	15,000,000	2,022,756	9,415,328	4,769,292	4,646,036	43,220,697	21,668,792	64,889,489	44,588,083	
1876	14,000,000	2,146,281	11,439,264	4,408,412	7,030,852	39,213,805	23,177,133	62,390,938	45,687,668	
1877	13,000,000	2,000,000	13,347,079	3,470,827	9,876,252	29,000,397	24,876,252	53,876,649	46,761,551	
1878	15,000,000	2,000,000	20,359,310	1,477,057	18,882,253	26,943,298	35,882,253	62,825,551	47,874,485	
1879	15,000,000	2,000,000	18,902,318	4,727,367	14,174,951	35,353,586	31,174,951	66,528,537		
1880	15,000,000	2,000,000	17,430,542	3,596,010	13,834,532	39,545,695	30,834,532	70,380,227	50,155,783	
1881	15,000,000	2,000,000	21,814,691	2,214,467	19,600,224	26,744,013	36,600,221	63,344,237		
1882	15,000,000	2,000,000	13,858,279	1,892,050	11,966,229	35,696,353	28,966,229	64,662,582		

STATISTICS OF SUGAR.

The magnitude of the sugar industry in the United States may be realized, by reference to the following statistics obtained from official sources.

In 1879, the sugar and molasses imported reached in round numbers the sum of $76,500,000, one-eighth of which was for molasses; a sum requiring more than the aggregate production of gold and silver of our mines, which, in 1880, was of gold $36,000,000, and of silver $39,200,000, a total of $75,200,000, or $1,300,000 less than sufficient to pay for the sugar imported the previous year.

In 1881, the raw sugar consumed in the United States amounted to 1,008,932 tons of 2,240 pounds, and in 1882 to 1,177,949 tons. About an eighth of this was produced in the United States.

The value of the importations in 1881 was as follows:

Sugar and Molasses	$ 88,432,083
Duties	47,984,033
Total	$136,416,116

The Director of the U. S. Mint gives the gold and silver produced in 1881, in the United States, as follows:

Gold	$36,500,000
Silver	42,100,000
Total	$78,600,000

Thus it will be seen that the sugar cost us, without duties, $9,832,083 more than the entire product of our gold and silver mines; and, since to the consumer the duties are to be added, it appears that our sugar cost, in 1881, $57,816,116 more than our gold and silver product.

In short, it is found that the amount of sugar consumed in the United States, since the discovery of gold in California, in 1848, has exceded the entire product of gold and silver of the United States during the same period, and has amounted to an aggregate of about $2,000,000,000.

So impossible is it for the mind adequately to grasp the amounts represented by such figures, that it may perhaps be more readily comprehended when we say, that the amount of sugar annually consumed in the United States would fill a continuous row of hogsheads extending nearly from Boston to Chicago.

The following table represents the total receipts of the United States for revenue and customs in 1881. It will be seen that the duty upon sugar amounts to 24.3 per cent of the total receipts for customs, and

to 14.6 per cent of the entire revenue of the government from both customs and revenue.

Internal Revenue Receipts, 1881.

Spirits	$67,153,975
Tobacco	42,854,992
Fermented Liquors	13,700,241
Banks and Bankers	3,762,208
Penalties, etc.	231,078
Adhesive Stamps	7,924,708
Other Articles	152,163
	$135,779,365

Customs Duties.

Sugar, Melada, and Molasses	$47,984,033
Silk Goods	19,038,666
Iron and Steel	21,462,534
Wool Stuffs	27,285,625
Cotton Stuffs	10,825,115
Flax Stuffs	6,984,375
Other Articles	59,980,663
	$193,561,011
	135,779,365
Grand Total	$329,340,376

Sugar equal 24.3 per cent of Customs.
" " 14.6 " " of Entire Revenue.

BIBLIOGRAPHY OF SORGHUM.

The following attempt has been made towards the chronological arrangement of the literature of sorghum, and, although it is confessedly imperfect, it will at least assist those who may desire to investigate for themselves the history of this plant.

Many of the most valuable articles have appeared in the current publications, of which it was obviously impossible to procure a record. At some future time the list may be brought to a condition more nearly complete.

BIBLIOGRAPHY OF SORGHUM.

(Chronologically arranged.)

Arduino Pietro. Memorie di osservazioni e di sperienze sopra la coltura e gli usi di varie piante, che servons o che servir possono utilimente alla tinctura all'economia, all'agricoltura, etc. Tomo I. Padova, 1766.

Child, David Lee. The Culture of the Beet, and Manufacture of Beet Sugar. Boston, 1840. 12°. p. 156.

Notiz über Mais-zucker. Annales maratimes et coloniales. Paris, 1842. II T., 2, p. 346.

Colman's Rural World. St. Louis, Mo., 1848 to 1884.

Montigny. Liste de l'envoie Bulletin du comice agricole du Toulon. 1853.

Holcus Saccharatus. Revue Horticole. 1854, February, July, and November.

Browne, D. Jay. Researches on Sorgho-Sucré, Department of Agriculture, Report, 1854, P. XII, and pp. 219–223.

Chinese Sugar-Cane. Correspondence, Department of Agriculture Report, 1855, pp. 279–285.

Barral. Ueber den Zucker in Holcus Sorghum. Moniteur industriel, 1855, p. 1919.

Ponsard. Verzuche mit Holcus Saccharatus. Moniteur industriel, 1855, No. 1939.

Reihlen. Ueber Holcus Saccharatus. Polytechnisches Centralblatt, 1855, p. 703.

Vilmorin, Louis. Le Bon Jardinier. 1855, p. 41.

Sorghum, Characteristics of. Massachusetts Agricultural Report, 1856, pt. 1, pp. 89, 91, 98.

Sorghum Saccharatum brought from China. Illinois Agricultural Report, 1856–'57, p. 446.

Browne, D. Jay. Crystallization of the juice of the Sorgho-Sucré. Department of Agriculture Report, 1856, pp. 309–313.

Jackson, C. T., M.D. Chemical Researches on the Sorgho-Sucré. Department of Agriculture Report, 1856, pp. 307–309.

Erfahrungen über die Kultur und Ausbeute von Zucker aus Sorghum. Moniteur industriel, 1856, No. 2049.

Turrel. Ueber das Sorghum in Nord-China. Moniteur industriel, 1856, No. 2110.

Zoulie. Ueber Sorghum. Moniteur industriel, 1856, No. 2110.

Madinier (P.) and (G.) Lacoste. Guide du cultivateur du Sogho-á-Sucré. Paris, 1856.

Madinier, M. Department of Agriculture Report, 1856, p. 313.

Vilmorin, Louis. Department of Agriculture Report, 1856, p. 312.

Browne, D. Jay. Report of the United States Agricultural Society. Department of Agriculture Report, 1857, pp. 181–183.

Sorghum, Experiments in the cultivation of. Massachusetts Agricultural Report, 1857, pt. 1, pp. 117–145, 149–215; pt. 2, pp. 38, 157, 170, 222, 225, 229, 234.

Sorghum Mills, Description of. Ohio Agricultural Report, 1857, p. 416.

Sorghum, Lovering's experiments on. Ohio Agricultural Report, 1857, p. 423.

Sorghum, Statement of, in Ohio. Ohio Agricultural Report, 1857, p. 437.

Hardy. Ueber Zucker aus Sorghum. Moniteur industriel, 1857, No. 2131.

Cavé. Ueber den Anbau von Sorghum auf dem Gute de Condé. Moniteur industriel, 1857, No. 2153.

Sorghum, Report on, at Fair. Ohio Agricultural Report, 1857, p. 142.

Sorghum Sugar-Cane. New York Agricultural Report, 1857, pp. 16, 128, 135.

Hyde, J. F. C. The Chinese Sugar-Cane. New York, 1857. 12°.

Sorghum Saccharatum. Pennsylvania Agricultural Report, 1857–58, pp. 147, 557.

Sorghum, History of. Ohio Agricultural Report, 1857, p. 409.

Sorghum discussed in annual convention. Ohio Agricultural Report, 1857, p. 195.

Sorghum or Chinese Sugar-Cane. Ohio Agricultural Report, 1857, p. 34.

Jackson, C. T., M.D. Chemical Researches on the Chinese and African Sugar-Canes. Department of Agriculture Report, 1857, pp. 185, 192.

Lovering, Joseph S. Sorghum Saccharatum, or Chinese Sugar-Cane. Detailed account of experiments and observations upon, 1857.

On the Identity and Hibridity of the Chinese and African Sugar-Canes. (Condensed from the proceedings of the Boston Society of Natural History.) Department of Agriculture Report, 1857, pp. 183–185.

Smith, J. Lawrence. Investigation of the Sugar bearing capacity of the Chinese Sugar-Cane. Department of Agriculture Report, 1857, pp. 192–196.

Sorghum Sugar, Condensed correspondence on. Department of Agriculture Report, 1857, pp. 196, 226.

Stansbury, Charles F. Chinese Sugar-Cane and Sugar Making. New York, 1857. 12°.

Sorghum Syrup, Statement in regard to making. New York Agricultural Report, 1858, p. 722.

Sorghum-Cane, Letters read at a convention on. Illinois Agricultural Report, 1858, p. 306.

Sorgham Cane. Wisconsin Agricultural Report, 1858–'59, pp. 261, 350, 409, 412.

Sorghum. New York Agricultural Report, 1858, p. 12.

Sorghum. Iowa Agricultural Report, 1858, p. 9.

Sorghum-Cane, Sugar from. Illinois Agricultural Report, 1858, pp. 107–109.

Sorghum-Cane, On. Illinois Agricultural Report, 1858, p. 512.

Olcott, Henry S. Sorgho and Imphee. The Chinese and African Sugar-Canes. A treatise upon their origin, varieties, and culture. New York, 1858, 12°, p. 352.

Jackson, Ch. T. Compte rendus, xlvi, p. 55. 1858.

Du Feyrat. Comparative Ausbeute aus Sorghum u. Zuckerrohr. Moniteur industriel, 1858, No. 2228.

Leplay, Ueber Sorghum u. dessen Zuckergehalt.
Moniteur industriel, 1858, No. 2334.
Comptes rendus, v. 46, p. 444.
Polytechnisches Centralblatt, 1858, p. 593.
Polytechnisches Jour. Ding. B, 148, p. 224.

Collectaneen über Zucker aus Sorghum.
Polytechnisches Jour. Ding., B. 148, p. 158.
Bulletin de la Société d'Encouragement pour l'Industrie Nationale, 1858, p. 505.
Polytechnisches Centralblatt, 1858, p. 1102.

Habich. Ueber Sorghum u. dessen Werth.
Polytechnisches Jour. Ding., B. 148, p. 302.
Polytechnisches Centralblatt, 1858, p. 1647.

Lovering. Ueber den Werth des Sorghums als Zuckerpflanze.
Moniteur Industriel, 1858, No. 2313.
Bulletin de la Société d'Encouragement pour l'Industrie Nationale, 1858, p. 673.

Sorghum Saccharatum. Essay on its composition. Michigan Agricultural Report, 1859, p. 213.

Wagner. Ueber den Mais als Zuckerpflanze. Agronomische Zeitung, 1860, p. 12.

Das Zucker-Sorgho, oder das chinesische Zuckerrohr (Holcus Saccharatus). Deutsche Gewerbezeitung, Wiecks, 1859, p. 443; 1860, p. 156.

Pierre. Ueber das chinesische Zucker-sorgho als Futter-u. Zuckerpflanze. Bulletin de la Société d'Encouragement pour l'Industrie Nationale, 1860, p. 94.

Anbauversuche mit der Zucker-hirse (Sorghum Saccharatum). Annalen der Landwirthschaft, Wochenblatt, Berlin, 1860, p. 350.

Cook, D. M. Culture and Manufacture of Sugar from Sorghum. Department of Agriculture Report, 1861, pp. 311–314.

Sorghum. Ohio Agricultural Report, 1861, p. 52.

Sorghum as an Exhauster of Soil. Ohio Agricultural Report, 1861, p. 526.
Sorghum as a Wine Plant. Ohio Agricultural Report, 1861, p. 526.
Sorghum, Growth and Manufacture. Ohio Agricultural Report, 1861, p. 210.
Sorghum Sugar. Warder's statement. Ohio Agricultural Report, 1861, p. 15.
Sorghum, Culture and Manufacture. Ohio Agricultural Report, 1861, p. 208.
Sorghum Sugar-Cane. New York Agricultural Report, 1861, p. 785.
Corn-stalk Sugar. Department of Agricultural Report, 1861, p. 275.
Sorghum Culture. Illinois Agricultural Report, 1861–'64, pp. 553–567.
Sorghum. Iowa Agricultural Report, 1861, p. 8.
Sorghum. History of. Ohio Agricultural Report, 1861, p. 206.
Sorghum as a Forage Plant. Ohio Agricultural Report, 1861, p. 527.
Sorghum Culture. Wisconsin Agricultural Report, 1861–'68, p. 35.
Goessmann, C. A. Chinese Sugar-Cane; contributions to the knowledge of its nature, etc. Transactions of New York State Agricultural Society, 1861, pp. 785–811.
Hedges, Isaac A. Sorghum Culture and Sugar making. Department of Agriculture Report, 1861, pp. 293–311.
Sorghum. Illinois Agricultural Report, 1861–'64, pp. 32, 67, 209, 859.
Bollman, Lewis. Cultivation of the Sorghum. Department of Agriculture Report, 1862, pp. 140–147.
Smith, J. H. Imphee and Sorghum Culture, and Sugar and Syrup Making. Department of Agriculture Report, 1862, pp. 129–140.
Statistical Report. Department of Agriculture Report, 1862, pp. 552, 553.
Syrup and Sugar Manufactured from Sorghum. Ohio Agricultural Report, 1862, p. 87.
Sorghum. Iowa Agricultural Report, 1862, p. 128.
Hedges, Isaac A. Sorgho, or the Northern Sugar Plant. With an introduction by Wm. Clough. Cincinnati, Ohio, 1862, 12°, p. 204.
Sorghum. Ohio Agricultural Report, 1862, p. 87.
Wetherell, Chas. M., M. D., Chemist Department of Agriculture. Report on Sorghum. Department of Agriculture Report, 1862, pp. 514–540.
Clough, Wm. Sorgho Journal, Cincinnati, Ohio, 1863 to 1869.
Gould, John Stanton. Report on Sorghum. New York Agricultural Report, 1863, pp. 735–769.
Wallace, G. B. Sorghum. Iowa Agricultural Report, 1863, p. 162.
Moss, James W. Sorghum. Iowa Agricultural Report, 1863, p. 244.
Sorghum, Essay on. Iowa Agricultural Report, 1863, pp. 137–244.
Gould, J. Stanton. Report on Sorghum and Sugar Beet Culture. Transactions of New York State Agricultural Society, 1863, pp. 735–769.
Sugar Evaporator and Mills. Ohio Agricultural Report, 1863, p, 100.
Sorghum Sugar, Protest from Exhibitors of. Ohio Agricultural Report, 1863, p. 101.
Sorghum. Iowa Agricultural Report, 1863, p. 4.
Sugar Mills, Ohio Agricultural Report, 1863, p. 85.
Clough. Wm. Sorghum, or Northern Sugar-Cane. Department of Agriculture Report, 1864, pp. 54–87.
Sorghum Mills. Ohio Agricultural Report, 1864.
Sorghum. Iowa Agricultural Report, 1864, p. 7.

Sorghum Mills. Report of Committee on. Ohio Agricultural Report, 1864, pp. 119, 120.

Collins, Varnum B. Sorgho, or Northern Chinese Sugar-Cane. Journal North China Branch Royal Asiatic Society, December, 1865, pp. 85–98. Shanghai, 1865.

Clough, Wm. Production of Sugar from Sorghum or Northern Sugar-Cane. Department of Agriculture Report, 1865, pp. 307–324.

Sorghum, Introduction into the State. Michigan Agricultural Report, 1865, p. 17.

Sorghum. Ohio Agricultural Report, 1865, pp. 14, 352.

Sorghum. Premiums awarded. Illinois Agricultural Report, 1865–'66, pp. 18–97.

Sorghum, Report of Committee on. Iowa Agricultural Report, 1865, p. 225.

Tenney, A. P. Sugar Question. Iowa Agricultural Report, 1865, p. 329.

Ives, Mrs. E. F. Essay on Sorghum making. Iowa Agricultural Report, 1865, p. 225.

Peck, F. Botanical history of Sorghum. Department of Agriculture Report, 1865, pp. 229–307.

Webster & Co., Sorgho Sugar-growers. The Culture and Manufacture of Sugar and Syrup from the Chinese and African Canes. Chicago, 1865 (?), 32°, p. 41.

Reed, W. History of Sugar and Sugar yielding Plants, and Epitome of Processes of manufacture. London, 1866.

Moser, J. Versuches Stationen, vol. 8, p. 93, 1866.

Jacob Brothers, Sorgho Manufacturers. Manual, etc. Columbus, Ohio, 1866.

Sorghum and its Products. Michigan Agricultural Report, 1866, pp. 169–172.

Sorghum in Delaware County. Ohio Agricultural Report, 1866, pt. 1, p. 188.

Sorghum and Imphee. Missouri Agricultural Report, 1866, p. 28.

Sorghum Mills. Illinois Agricultural Report, 1865–'66, p. 202.

Sorghum, Report of Committee on. Iowa Agricultural Report, 1866, p. 133, 223.

Sorghum, Report of Standing Committee on. Iowa Agricultural Report, 1866, p. 223.

Sorghum Sugar Making. Ohio Agricultural Report, 1866, pt. 2, p. 287.

Stewart, F. L. Sorghum and its Products. Philadelphia, 1867, 12°, p. 240.

Sorghum and its Products. Michigan Agricultural Report, 1867, pp. 65–67.

Sorghum, Report of Committee on. Iowa Agricultural Report, 1867, p. 18.

Sorghum, Resolutions and Report in regard to. Michigan Agricultural Report, 1867, pp. 305–307.

Sorghum and its Products. Missouri Agricultural Report, 1867, p. 92.

Sorghum and Machinery, Awards on. Ohio Agricultural Report, 1867, p. 138.

Sorghum. Ohio Agricultural Report, 1867, pp. 62, 246; pt. 2, p. 16

Sorghum of Van Wert County. Ohio Agricultural Report, 1867, pt. 1, p. 158.

Sorghum and Machinery. Ohio Agricultural Report, 1868, p. 97.

Sorgho, The Journal and Farm Mechanic. Cincinnati, Ohio, Feb., 1869, 8°

Sorghum, Committee on. Iowa Agricultural Report, 1869, pp. 190–195.

Sorghum, Products of. Iowa Agricultural Report, 1869, p. 17.

Sorghum, Report of Committee on. Iowa Agricultural Report, 1869, p. 179.

Sorghum, Secretary's Report on. Iowa Agricultural Report, 1869, p. 16.

Sorghum and Imphee. Wisconsin Agricultural Report, 1869, p. 27.
Sorghum. Iowa Agricultural Report, 1869, p. 16; 1870, p. 189.
Bretschneider. Notes on History of Plants and Chinese Botany. Peking, 1870.
Sorghum Syrup. Wisconsin Agricultural Report, 1870, p. 34.
Sorghum and its Products. Michigan Agricultural Report, 1870, p. 149.
Sorghum, Statement as to. Iowa Agricultural Report, 1871, pp. 205–212.
Sorghum, Report of Secretary on. Iowa Agricultural Report, 1871, p. 23.
Sorghum Sugar and Syrup, Report on. Iowa Agricultural Report, 1871, p. 204.
Sorghum. Abstract of County Agricultural Societies. Iowa Agricultural Report, 1871, p. 300.
Skinner, E. W. Sorghum. Iowa Agricultural Report, 1872, p. 290.
Sorghum Syrup and Sugar, Report of Committee on. Iowa Agricultural Report, 1872, p. 325.
Cadwell, Phineas. Report of Committee on Sorghum and its Products in Iowa. Iowa Agricultural Report, 1872, p. 286.
Sorghum Plant. Nebraska Agricultural Report, 1873, p. 89.
Sorghum, Abstract of Report on. Iowa Agricultural Report, 1873, p. 313.
Sorghum, The Production of. Nebraska Agricultural Report, 1873, p. 89.
Sorghum, Table of Products and Acreage. Kansas Agricultural Report, 1873, pp. 89–126.
Sorghum, Abstract of Report on. Iowa Agricultural Report, 1874, p. 304.
Sorghum. Ohio Agricultural Report, 1874, pp. 254, 636.
Basset, N. Guide Pratique du Fabricant de Sucré Paris, 1875, 3 vols., 8°.
Sorghum, Number of acres in. Georgia Agricultural Report, 1873–'75, p. 9.
Sorghum, Abstract of Report on. Iowa Agricultural Report, 1875, p. 281.
Sorghum. Tables of Product and Value. Kansas Agricultural Report, 1875, pp. 464–469.
Sorghum. Diagram showing Product and Value. Kansas Agricultural Report, 1875, p. 460.
Sorghum. Georgia Agricultural Report, 1876, p. 222.
Sorghum, Abstract of Report on. Iowa Agricultural Report, 1876, p. 312.
Sorghum, Report of Committee on. Iowa Agricultural Report, 1876, p. 224.
Stewart, F. L. Maize and Sorghum as Sugar Plants. Department of Agriculture Report, 1877, pp. 228–264.
Sorghum Molasses, Gallons of. Virginia Agricultural Report, 1877, p. 43.
Sorghum, Abstract of Report on. Iowa Agricultural Report, 1877, p. 271.
Collier, Peter. Sorghum. Department of Agriculture Report, 1878, p. 98.
Maumené, E. J. Traite theorique et pratique de la Fabrication du Sucré. Paris, 1878, 2 vols., 8°.
Stewart, F. L. Sorghum Sugar made from Maize, etc. Washington, 1878.
Sorghum. Virginia Agricultural Report, 1878. p. 31.
Sorghum, Abstract of Report on. Iowa Agricultural Report, 1878, p. 386.
Sorghum. Introduction into the country. Kentucky Agricultural Report, 1878, p 144.
Collier, Peter. Sorghum. Department of Agriculture Report, 1879, p. 36.
Sorghum, Abstract of Report on. Iowa Agricultural Report, 1879, p. 315.
Sorghum, Production of. Kentucky Agricultural Report, 1879, p. 64.

Goessmann, C. A. Early Amber Cane. Report Massachusetts Agricultural College, 1879.

Sorghum, Sugar from. Vermont Agricultural Report, 1879–'80, p. 260.

La Sucrurie Indigine, Extraction du Sucré du Sorgho et du Mais, 1879, p. 130.

Collier, Peter. Sugar from Sorghum. Vermont Agricultural Report, 1879–'80, p. 219.

Stewart, F. L. Sugar from Maize and Sorghum. Washington, D. C., 1879, 12°. p. 102.

Drummond, Victor A. W. Report on the Production of Sugar from Sorghum, 1879.

Sorghum-Cane. Proceedings of the Wisconsin Sugar Cane Growing and Manufacturing Association. Wisconsin Agricultural Report, 1879–'80, p. 463.

Sorghum Sugar. Report on, to Johnston, Hon. J. W., Chairman of Committee on Agriculture in United States Senate, 1880.

Blymyer Manufacturing Company. Sorgho Hand-Book. Cincinnati, Ohio, 1880.

Clough Refining Company. Clough Refining Process for Sorghum, etc. Cincinnati, 1880.

Collier, Peter. Corn-stalk and Sorghum Sugar. Abstract of an address delivered in the House of Representatives, Hartford, Conn., February 17th, 1880, Pamphlet, 8°, p. 23.

Collier, Peter. Sorghum and Corn as Sugar Producing Plants. Address delivered before the Connecticut State Board of Agriculture, at Willimantic, 1880. Pamphlet, 8°, pp. 23.

Sorghum: Sweets of Wisconsin. Wisconsin Agricultural Report, 1880–'81, p. 331.

Sorghum, Statistics of. Quarterly Report. Kansas Agricultural Report, 1880, pp. 21, 22.

Sorghum, Productions of. Kentucky Agricultural Report, 1880, p. 140.

Collier, Peter. Sorghum. Department of Agriculture Report, 1880, p. 37, and Special Report, No. 33.

Ingram, W. Sorghum Cultivation in Belvoir. London, 1880.

Department of Agriculture. Preliminary Report, 1880.

Collier, Peter. Department of Agriculture Report, 1881, p. 17.

Hedges, Isaac A. Sugar Canes, and their Products. St. Louis, Mo., 1881.

Rutger's Scientific School. Seventeenth Annual Report, 1881, p. 63.

Tucker, J. H.; Ph.D. A Manual of Sugar Analysis, including the Application in general of Analytical Methods to the Sugar Industry. New York, 1881, 8°, p. 353.

Weber and Scovell, Professors. Sorghum. Report on the Manufacture of Sugar, Syrup, and Glucose, from. Illinois Industrial University, 1881.

Vilmorin, Andrieux. Le Sorgho sucré de Chine et le Sorgho hatif du Minnesota, ou Sorgho sucré ambré. Journal d'Agriculture practique, May 8th, 1880, and February 17th, 1881.

Spon's Dictionary. Article, Sorghum. London, 1881.

Ware, L. S. A Study of the Various Sources of Sugar. Philadelphia, 1881.

Sorghum, Sugar from. Kentucky Agricultural Report, 1881, p. 83.

Sorghum, Cultivation and Manufacture of. Kentucky Agricultural Report, 1881, p. 72.

Kolischer, Theo. Sorghum, Sugar from. Kentucky Agricultural Report, 1881, p. 86.

Locke, Wigner, and Harland. Sugar Growing and Refining. London, 1882.

Experimental Farm, Madison, Wisconsin. Experiments in Amber Cane, 1882.

Biot and Soubeiran, Zucker in Mais. Polytechnisches Jour. Ding., 86 s., 213.

Pallas. Mais Zucker. Polytechnisches Jour. Ding., 94 s., 326. Brévetés d'invention. Paris, T. 46, p. 146.

Vorschlag. Zu einer Production von Zucker aus Holcus Sorghum. Technological Repository, Gill v. 10, p. 119; Franklin Jour., 1 s., v. 1, p. 201.

Pallas. Zucker aus Mais. Polytechnisches Jour. Ding., 63 s., 156; Jour. des con. usul. et prat., Paris, T. 26, pp. 97, 109.

Neumann. Zucker aus Mais. Polytechnisches Jour. Ding., 67 s., 300.

Collier Peter. Department of Agriculture Report, 1881–'82, p. 379.

Van Buren, Thomas B. Sorghum in Japan. Commercial Reports, Consuls, 1882, No. 25, p. 97.

National Academy of Sciences. Report of Committee on Sorghum Sugar Industry. Washington, 1882.

Report. Miss. Valley Cane Growers' Association. St. Louis, 1882.

Report. Wisconsin State Cane Growers' Association. St. Louis, Mo., 1883.

Report. Northern Cane Growers' Association of New York. Elmira, N. Y., 1883.

Collier, Peter. Sorghum as a Sugar Producing Plant. Special Report Dep't of Agric., 1883.

Sorghum and Beet Root Sugar Industry. Department of Agriculture. Special Report, 1883.

Storer, F. H. Sorghum Sugar. The Nation, vol. 31, p. 58.

Kittell, T. P. Sorghum. Hunt's Merchants' Magazine, vol. 48, p. 17.

CHAPTER III.

(*a.*) History of Sorghum.
(*b.*) Botany of Sorghum.
(*c.*) Introduction of Sorghum into the United States.
(*d.*) Hybridization of Sorghum.

HISTORY OF SORGHUM.

This interesting and valuable plant, which, for one purpose or another, has been cultivated, from the earliest historic periods, over an extent of territory as wide as that occupied by any of the other cereals, is in its early history very obscure. It origin is supposed to have been in India, the fruitful source of so many other cultivated plants; and thence it has been carried over a large portion of Asia, Europe, and Africa. Cultivated not only in India, but China, over the wide territory of Central Asia, Syria, and Arabia, and thence into Africa and Europe, until it occupied nearly the whole of Africa and the southern half of Europe, this plant has supplied the wants, as food or forage, of perhaps as large a number of the earth's population as any plant. Although its great value has so long been known, it appears destined to be, in the future, of far greater value to the agriculturist than it has been in the past.

Whether or not the many varieties of this plant now in existence have resulted from a common origin, remains, and perhaps must remain, an open question. Certain it is, that the numerous varieties, together with the closely related species, have long engaged the attention of botanists. The following quotations will show some of the points in the history of this plant.

In his "Principal Plants used as Food by Man," Dr. F. Unger says:

The common Indian millet (Sorghum vulgare, Pers.) was introduced into Egypt by Arabians, and is a characteristic plant of Africa, not because it was originally indigenous there, but because it is principally cultivated in this country, on the east and west coast of the northern half to Timbuctoo; in Abyssinia, from sea level to 8000 miles elevation. Although its native country can not be positively ascertained, it can scarcely be any other land than India. Even in the time of Pliny it was known in Europe, and in the 13th century had extended to Italy, and at beginning of 16th century reached France under name of Saracen millet. It is now grown in Hungary, Dalmatia, Italy, Portugal. The different varieties of the Indian millet, however, are not well defined at the present day. It is doubtful whether the Sorghum bicolor, Willd, and the Sorghum Usorum, Nees, are entitled to a specific rank.

In his "Manual on Physical Geography," Professor Gustav Adolph von Kloeden, Berlin, 1866, says:

Sorghum (Holcus) saccharatum (Halapense andropogon), a variety of S. vulgare, or of the Durrha, is the sugar-cane of Northern China, and by the Zulu Kaffirs called Imphee. The Japanese cultivate it only for the sugar and the alcohol, and for that purpose it is now cultivated in the United States. In the year 1851, this plant became first known in Europe. In France, it is cultivated in the Drome, East Pyrenees, the upper Marne, Gironde, Gers, etc., also in Algeria, where it is extensively cultivated. It grows from 9 to 18 feet in height. When the cane is cut, there grow 5 to 20 canes from the root. It is an excellent food for cattle.

The seed coming from the East Indies, are used in England for puddings. From the common Durrha the Kaffirs make a flour, and they plant close by their huts 15 varieties of the Imphee, which they chew for the sweet juice. They call it also Mabali. The stronger varieties seem to be Koom-ba-na, Shla-goon-dee, and Oom-see-a-na; the tallest are the Vim-bis-chu-a-pa and E-a-na-moo-dee.

This variety of Sorghum grows also in Nubia, and in the Oases, and it is called in Egypt Bali, Arabic Durrha. In Egypt, there are six varieties cultivated.

The common Sorghum (vulgare) is the principal grain food in Africa: it is made into bread, or eaten as mush. It is the principal nutriment in many parts of India, where it is called Jovari, and in the dry regions of Arabia, in Syria, where it has been cultivated since time immemorial. In Egypt, Nubia, where it is called Durrha, it grows from 5 to 20 feet in height, and in Senegambia, where it reaches 15 feet in height. It is cultivated in Hungary, Dalmatia, Italy, and Portugal. In the West Indies, it is called Guinea Corn. In China and Cochin China, the S. saccharatum is also cultivated. Marshilla, Sorghum bicolor, is cultivated in Abyssinia at 8,000 feet above the sea. In Borneo, they grow a kind called *gussub*, which is used exclusively as food, and they make the Kaddel from it as a delicacy. The Nubians make from the sorghum a fermented beverage called Buzah.

Chambers' Encyclopædia says:

The common Durra, Doura, Durra Millet, Indian millet, Sorghum, S. vulgare, or Andropogon sorghum, Holcus sorghum, Joar and Jowaree, in India, native of East India; cultivated extensively in Asia, and may be called the principal corn plant of Africa. Also cultivated largely in South Europe. Rival of maize in amount of seed. Leaves and seed are used as food for horses and cattle.

The seeds of the Shaloo or Sugar Grass (S. saccharatum) are more pleasant than those of Doura to taste. It is cultivated in warm parts of Asia and Africa, and has diffuse and very spreading panicle. The moist pith is eaten. It is cultivated in the United States as Chinese sugar-cane. Kaffir-corn (S. caffrorum) has a very diffuse umbel-like panicle, with branches bending down all around. Has sweet pith. Largely cultivated in South Africa, both by Caffers and colonists. By latter, the grain is used for horses.

Dr. S. Wells Williams, the distinguished Chinese scholar, in a communication to the Committee of the National Academy of Sciences, engaged in the investigation of the "Sorghum Sugar Industry," in reply to the question, "Is it known how long sorghum has been cultivated in China as food, or for making spirits?" says:

To this question it is hard to make any satisfactory reply, inasmuch as no Chinese books contain illustrations of grains or plants used in ancient times, nor are there found among their monuments pictures of these similar to representations of ancient Egypt, Assyria, Greece, etc.

As to the history of this grain in China, Dr. Bretschneider, of the Russian legation at Peking, and foremost among the authorities upon Chinese botany, says (concerning the plant called Shu): "This cereal is separately described in the *Pun Tsao* (Chinese Herbal), published A. D. 1570. The grain is called Hwang-mi, and is said to possess much glutinous matter. It is used for manufacturing alcoholic drinks. This corn was known to the Chinese in the most ancient times. It seems to me that the meaning of the character Shu, in ancient days, was not glutinous millet (as Dr. Legge states in the *Shu King*), but rather *sorghum*, as Dr. Williams translates."* If this deduction is true, the cultivation of this plant dates from about 2000 B. C. The precise uses of this grain in ancient times can only be inferred.

If the identity of the Shu (mentioned in the classics) with sorghum could be proved beyond question, this grain would rank in age as grown in China with any in the world.

Sorghum is seldom used in China now as food for man; the great food staples of Northern China are wheat, pulse, maize, and Italian millet (Setaria). Buckwheat, panicled millet, and the sweet potato, may be included as secondary staples. Rice is imported to the north from the southern provinces.

I have never seen the broom corn grown in China.

The twenty or more varieties which President Angell brought from China could, probably, be increased in number if the collection were made from a more extended area.

The uses of this plant for fuel, tend to increase attention to the development of its stalk rather than the grain.

The plant often attains a height of 15 or 16 feet. The common practice of stripping off all the leaves within reach upon the growing stalk, for feeding cattle, increases very materially its woody fiber. Cutting the stems while in their prime of growth, and chewing them green, as southerners do the sugar-cane, is not unusual in the north.

The Chinese do not possess the art of refining sugar or making syrup to perfection. Even in the cane-growing districts their employment of molasses is small; none of this is ever made from sorghum, to my knowledge.

---

*As to the sugar-cane, the same writer adds: "I have not been able to find any allusion to it in the most ancient of Chinese works (the five classics); it is first mentioned by writers of the second century B. C. * * * One says, 'it grows in Cochin China. It is several inches in circumference, ten feet high, and resembles bamboo. The juice is very sweet, and, dried in the sun, changes into sugar.'"

Dr. E. Bretschneider, physician to the Russian legation at Peking, who is quoted in the foregoing notes from Dr. Williams, says, in his essay, or memoir, on the study and value of Chinese botany, page 46:

The true sugar-cane (Saccharum officinarum) growing in China, must not be confounded with what is called Northern China sugar-cane. This is Sorghum saccharatum, a plant now-a-days largely cultivated in Europe and America for the purpose of manufacturing sugar from it. This plant was first introduced from Shanghai into France by the French consul, M. Montigny, in the year 1851, whence it spread over Europe and America, after it was proved that it is very rich in sugar.

Dr. Bretschneider then relates substantially the same statements respecting Mr. Collins astonishing the natives by making sugar from sorghum, which Dr. Williams also mentions.

On page 45, after discussing the meaning of the Chinese terms applied to these plants, he adds, in conclusion:

It seems to me that the meaning of the character translated Shu in ancient times, was not glutinous millet (as Dr. Legge states in his translation of the *Shu King*), but rather sorgho, as Dr. Williams translates.

It seems, then, that the term Chinese sugar-cane is a misnomer, only so far as the plant was not recognized as a sugar producing plant by the Chinese, while the original seed of the Sorghum saccharatum, according to these authorities, was undoubtedly imported into France from China.

The above statement is very interesting, in connection with the names of those varieties of sorghum received through President Angell from Northern China. Each of these was called Liang, which was interpreted *millet*, though they were, undoubtedly, specimens of sorghum. As will be seen, however, Dr. Williams mentions *panicled millet* as one of the secondary staples grown in China. Besides the common name Liang, the additional names, Hwong-mao-nien, translated yellow-cap-glutinous, were given; and the name of the grain grown by Dr. W. is Hwang-mi.

In this connection, the following quotation from a letter received from John Thorne, Esq., is of interest. It would appear that, if the identity of Hwang-mi and Hwong-mao was established as the grain of the plant "Shu," that the cultivation of sorghum in China is verified by historical evidence extending back nearly 4,000 years.

The note of Dr. Collier I inclose, and note what he says about the meaning of the word in Chinese. I fancy Hwang-mao the same as H. mi, or, better, "*shu*," which is a radical, and means millet. See Williams' Ch. Dict'ry, Rad.

202. The appearance of the grain is cap-like, growing in even rows, corn high, and beautiful to look at, in all of the North China provinces.

I have not seen it, except to a limited extent, in the provinces watered by the great river (Yang Tse).

Dr. Williams' Report, p. 57, is a very accurate one, and I can add nothing thereto. "Pao Liang," which is also understood in China as a millet production, is a spirituous liquor much used by the Chinese, north, south, east, and west. I have tasted it, but, like all the Chinese distillations, in failing to purify from "must," is objectionable. Other grains are also distilled in China; but none, I think, to the same extent as the millet plant.

BOTANY OF SORGHUM.

In the Annual Report of the Department of Agriculture, 1865, p. 299, F. Pech has collected many historical and botanical references to sorghum, which have been verified by reference to the several authorities, and are here appended. Pliny the elder, who lived in the first century, in his Natural History, Lib. XVIII, ch. 10, says:

Milium intra hos decem annos ex India in Italiam invectum est, nigrum color, amplium grano, arundineum culmo. Adolerat ad pedes altitudine septem, praegrandibus culmis lobas vocant, omnium frugum fertilissimum. Ex uno grano sextarii terni gignuntur. Seri debet in humidas.—Within the past six years, a millet has been imported into Italy from India, of a black color, abounding in seed, and with a reed-like stalk. It attains a height of seven feet, and has very large stalks, which they call lobas; and of all grain it is the most fruitful. From a single kernel, about three pints of seed is produced. It should be planted in moist ground.

And a note appended to the above, by Scaliger Exercit, 292, p. 869, says:

Hoc sorghum vocari apud nos populares.—This plant is called sorghum among our people.

The name *milium*, or millet, means *thousands*, referring to its numerous seeds, and is, of course, as applicable to sorghum as to millet, and was, probably, applied originally to all plants of this general character.

Pliny, 32nd chap., Book VI, speaking of Insulae Fortunae (Canary Islands), asserts, on authority of Juba:

Arbores similes ferulae, ex quibus aqua ex premitur, ex nigra amare, ex candidioribus jucunda.—Trees similar to the giant fermel, from which juice is expressed, which from the black variety is bitter, and from the whiter variety is sweet.

Since sugar-cane is not reported as having been introduced upon these islands earlier than 1420, it would appear that the above reference of Juba must have been to the sorghum.

Fuchius, of Belgium, describes, in his History of Plants, in 1542,

a plant under the name of Shorghi, which is precisely the true popular name of the Sorgho in the East Indies.

Jerome Fragus, in describing the plants of Germany, in 1552, gives the description of the same plants, under the name of "Panicum Dioscorides et Plinii" (bread millet of Dioscorides and Pliny), thus showing that the plant referred to by Pliny was the same as that mentioned by Dioscorides, the Greek, and was already cultivated in Germany.

Conrad Gesner, in his Hortus Germania (German garden), in 1591, names the same plant Sorghum.

Matthioli, an Italian, in his Commentaries on Dioscorides, in 1595, describes it under the name of Milium Indicum (Indian millet).

Lobel, a Belgian, in 1576, describes the plant as the "Sorgho melica Italorum" (sweet sorghum of the Italians).

Dodon, a Belgian, in 1583, in his Pemptades, names it "melica, sive sorghum" (honey, or sorghum).

It will be observed, here, that a distinction is made in these plants, then cultivated in Italy and Germany—reference being made to the sweet character of one variety. And a Roman writer, Lucian, the Syrian poet, who wrote about the second century, says, verse 237, Book III, "Quique bibunt tenera dulces ab arundine succos" (Those who drink the sweet juices from the tender cane), may refer to Sorghum saccharatum.

Belloni speaks of it as Sorghum Insubrum, thus locating it as already established in Northern Italy.

Lonicer, a German, 1589, and Gerarde, an Englishman, 1597, describe several varieties of sorghum, as sorghum panicum loculere.

Bester, a German, 1613, also describes it as milium Plinii: thus showing that the plant described by Pliny had been cultivated in Europe from his day down to the seventeenth century.

In 1623, Gasper Bauhin, in his Pinax, includes all the above names as synonyms, under the descriptive phrase of "milium arundinaceum subrotundo semine, sorgo nominatum" (a reed-like millet, with nearly round seed, called sorgo), and with the observation, that the seed varies in color from a brownish red to black, and from white to yellow; these names represent one or more species.

And, in his Historia Plantarum, Liber XVIII., Art. Sorghi, Bauhin, says of the seed:

"Appensa haeret copiosissima, quae lentibus aequalia compressa non nihil oblonga, nunc alba, nunc fusca et quandoque nigra."—It is in the greatest

abundance, and is compressed similar to lentils, somewhat oblong in shape, white, dark, and sometimes black in color.

And of the stalk, he says:

Eius tamen calamus, non ut vulgarium arundinum inanis est, sed sacchariferarum arundinum modo, alba farctus medullà.—Yet the stalk of this reed is not worthless, like the common reed, but is, in fact, a sugar bearing reed, filled full of a white pith.

And he quotes Dodonius as saying, in Hist. Lat. Frum:

Melica, siva sorghum, Lusitanis milium Saburrum appellatum non nulli tamen Panicum peregrinum at Indicum cognominant.—Melica, or sorghum, called by the Lusitanians Saburrum millet, yet sometimes they call it foreign, or Indian Panicum.

And he concludes as follows:

Nos eorum sententiam probamus qui milium Indicum Plinii esse concludent.—We agree with the opinion of those who consider it to be the Indian millet of Pliny.)

Frequent reference is made to the white, sweet incrustations upon the joints of an Indian reed, to which the name Saccharum was given by Dioscorides; and which is supposed to be the earliest reference to sugar. It is probable that this substance was similar to, if not identical with, a similar exudation from the joints of a hollow reed growing in our Western territories, and which is annually gathered, in considerable quantity, by the Indians, and is known as Piute sugar. It is allied to manna in composition, and is not cane sugar.

Besides the many quotations given, there are many others which could, with equal force, apply to either the sugar-cane or the sorghum, as, for example, Varro (68 B. C.), says:

India non magna nimis arbore crescit arundo illius è lentis primetur radicibus humor dulcia qui nequeant succo condendere nulla.—There grows, in India, a reed, not much less in size than a tree, from the pliant stalks of which is expressed a juice which the sweet honey can not surpass.

From Bauhin to the present day, botanists have been more careful in their determinations of those plants so closely allied.

Linnæus places them under his genus Holcus, under the specification of H. sorghum for the Indian millet, and H. saccharatum for the Chinese cane.

Persoon, after a careful study of these plants, has divided the Linnæan genus Holcus to form a new one, which he calls Sorghum.

The name sorghum is from Shorghi, the common name of the plant in the East Indies.

Botanical Description.

Generic characters: Spikelets (flowers with their husks at the end of the small branches), two or three together on the slender ramifications of the panicle (seed head), the lateral ones abortive, or reduced to a mere pedicel; the middle or terminal ones fertile. Glumes (the husk or hull) coriaceous (leathery), closely bearded or downy, becoming indurated after the anthesis (blooming), with or without awns. Palea (inner husk) membranous; stamens, three; styles, two, with bearded stigmas. Stout, tall grasses, with solid stalks with pith.

Specific Name, Sorghum Saccharatum.

Botanical Names.

Milium quod ex India, in Italiam invectum, nigro colore.—Pliny.

Sorgo melica Italorum.—Lobel.

Melica, sive sorghum.—Dodon.

Melica forte a milica sagina, aliis saginanda calamagrostis Dioscorides.—Coesalpin.

Milium arundinaceum sub rotundo semine, sorgo nominatum.—G. Bauhin.

Sorghum.—Rumphi.

Milium Indicum arundinaceo caule, granis flavescentibus.—Herman.

Holcus saccharatus.—Linnæus.

Milium Indicum sacchariferum altissimum seminibus ferrugineo.—Breynuis.

Holcus dochna.—Foskal.

Holcus caffrorum.—St. Clair.

Andropogon saccharatum.—Kuntz.

Sorghum saccharatum —Persoon.

Holcus caffrorum.—Thunb.

Holcus caffir.—Arduini.

Sorghum Arduini.—Jaquas.

Sorghum caffrorum.—Beauvois.

Description of Plant.

Root, fibrous; culm (stalk) thick, stout, solid, with pith, from six to twelve feet high; leaves lanceolate, acuminate, downy at base; flowers forming a large, more or less diffusely spreading panicle, with the branches more or less verticillate, often nodding when in fruit; glumes (husk) of the perfect flower hairy, downy, and persistent; from the East Indies. Cultivated.

William Henry Harvey, F.R.S., in "The Genera of South African Plants," London, 1868, gives the generic characters of this plant as follows:

Sorghum.—Spikelets at the ends of twigs of a branching panicle—either female, male, or neuter—dissimilar. Outer glumes, two; in the fertile and male spikelets coriaceous, hardening with scarcely obvious immersed nerves; in the neuter spikelets membranous, nerved; flowering glumes thinly membranous ciliate, the lower neuter, the upper fertile, with a short twisted awn, or awnless. Palea small, narrow scales, fimbricate. Seed thick, short, hard, closely wrapped in the hardened glume and palea.

Nees, l. c., p. 85:

Tall, strong, broad-leaved grasses, with villous or pubescent glumes; grain used as food in India.

Holcus caffrorum, described by Thunberg, in his "Flora Capensis," and later (1780) introduced from South Africa into Italy by Peter Arduino, was found by Sprengel to be identical with S. saccharatum, to which he also referred S. arduini, Jaqu., and the S. caffrorum, Beauv.

Nees agrees with Sprengel; but states decidedly that two distinct species are cultivated on the Cape of Good Hope; as is seen from a note appended to his description of the following species: "Species altera in hortis Coloniae culta quae Holcus caffrorum. Thunb. Flora. Cap."

Sorghum Usorum. N. v. E.

This species, referred to above by Nees, has been described by Thunberg, in his Prodromus Floro Capensis, as Holcus caffrorum, and has subsequently been mentioned as S caffrorum panicula compactiori. Roem and Schlut.

Recognizing it as a proper species in his Agrostographia Capensis, Nees applied to it the name of the Caffir tribe, "Us," among whom Drege found the plant extensively cultivated.

Dr. Charles Mohr, of Mobile, Ala., who has recently investigated the subject, writes, that

There can scarcely be any doubt that all the South African varieties, with more or less closely contracted panicles, can be referred to this species. The many forms under cultivation can be reduced to those specifically distinct types. Adopting the view that Sorghum vulgare is the parent plant of these species, and all of them can be separated in two races, distinct in habit and geographically in their ancestry, as has already been shown by Pech, in his Botanical History of Sorghum (Annual Report, Department of Agriculture, 1865):

1. The race of the sorghos chiefly of Asiatic origin, with the branches of the expanded panicles more or less drooping, characteristic of the Sorghum saccharatum.

2. The race of the Imphees, or the exclusively African race, the closely contracted panicle more or less dense, with erect adpressed ramifications, the type of Sorghum Usorum.

By the crossing of these races, and the inter-crossing of the resulting hybrids, many varieties have been produced. Introduced into regions of different latitudes, exposed to influences of various conditions of climate and soil, these were subjected to further modifications, which, permanently retained by inheritance through future generations, show their peculiarities less in the morphological features than in their physiological relations, of much more importance to the cultivator, by their influence upon the life of the plant and the product of its activity. In the endeavor to attain those modifications which shall appear most favorable under given conditions, in respect to the time required for ripening, the percentage of sugar, and also the capacity of resisting unfavorable influences, the number of permanent variations is constantly increasing in the United States.

The difficulty of assigning them their proper places, and discovering their relationship and ancestry, increases with the obliteration of the original type.

In general, the following well established varieties can be regarded as belonging to the first of these races: regular Sorgho, Chinese sugar-cane, Honduras, Mastodon, Honey cane, Sprangle top, Honey-top, Link's hybrid, and other varieties produced by crossing with varieties of African ancestry with rather expanded panicles.

To the second, or the African race, belong the Liberian, Imphee, Oomseeana, Neeazana, White African, with the varieties produced in this country known as Black top, Bear tail, Iowa Red top, White mammoth, Wolf tail, Gray top. The Early Amber and Early Orange are forms of prominently African type. The identification of these various sorts is extremely difficult, and can only be accomplished by artificial methods, regardless of their natural affinities, as has been successfully attempted by Dr. Collier.

C. G. Nees ab Esenbeck, in his Agrostographia Capensis, 1853, p. 86, classifies the sorghums as follows:

1. *Sorghum bicolor.*—Willd.
   Holcus bicolor.—Willd.
   Andropogon cernus.—Kunth.
2. *a. Sorghum saccharatum.*—Pers.
   Sorghum saccharatum.—Pers.
   Holcus saccharatus.—Kunth.
   Holcus Caffrorum.—Thunb.
   Holcus Caffer.—Arduini.
   Sorghum Caffrorum.—P. de Beauv.
   Sorghum Arduini.—Jacq.
   Holcus dochna.—Forsk.

   b. Rubens.
   Sorghum rubens.—Willd.
   Andropogon rubens.—Kunth.
3. *Sorghum Usorum.*—N. ab. E.
   Holcus Caffrorum.—Thunb.
   Sorghum Caffrorum panicula compactiori apud.—R. et Sch. S.
4. *Sorghum halapense.*—Pers.
   Holcus halapensis.—Sibth.
   Trachypogon avanaceus.—N. ab E.

Andropogon halapensis.—Kunth.
Andropogon avanaceus.—Michx.
Blumenbachia halapensis.—Köhl.

Bentham, in Genera Plantarum, III, p. 1135, considers the whole genus sorghum as comprised in two species, S. vulgare and S. halapense.

This final conclusion of such eminent authority, is evidence of the plastic nature of this plant, which, by variations, has adapted itself to the various climatic conditions under which it is grown, and gives reason to hope that, in the hands of the intelligent cultivator, it may develop other varieties more valuable for the purpose of sugar production than any now known.

The genus Sorghum (of which Sorghum vulgare is the accepted type) is included in the natural order Graminaceæ, to which natural order belongs, also, the tropical sugar-cane (Saccharum officinarum); but it should be remarked that, between the genus Sorghum and the genus Saccharum, there are classed by botanists the three genera, Erianthus, Eriochrysis, and Ischaemopogon. Vid. Grisebach's Flora of the West India Islands, pp. 560, 561.

While, therefore, the two plants are somewhat closely related, this relationship does not warrant the assertion made by a recent writer upon this subject, "that the name sorghum is a mere disguise, for the reason that it is nothing more nor less than a sub-variety of sugar-cane, which may explain why it is that the reader and the investigator have so frequently been misled."

To the unscientific observer, a growing sorghum plant would seem to combine many of the exterior characteristics of sugar-cane.

I here append parallel statements, prepared by Dr. George Vasey, Botanist of the U. S. Department of Agriculture, which show the differences between the genera Sorghum and Saccharum, upon which botanists base the opinion that *sorghum is not "a sub-variety of sugar-cane."*

Sorghum vulgare.

Flowering spikelets, two or three together, on the ends of the branches of an open panicle; these spikelets are of two kinds, viz., one sessile, single flowered, fertile spikelet, and accompanying this, one or two others, which are short stalked, or pediceled, and contain male flowers, or sterile flowers; or sometimes these disappear, leaving only the stalks or pedicels. The fertile spikelet consists of a pair of thick, coriaceous or hard glumes, and of two very thin hyaline palets, one of which usually has a twisted awn or beard, twice as long as the spikelet. In some varieties, the glumes and seed are more or less hairy, and in others nearly smooth. The seed is large and round.

Saccharum officinarum.

The flowering spikelets are placed, at short intervals, on the joints of long, slender branches of the panicle, usually in pairs, one of which is sessile, and the other pedicellate. They are each surrounded at the base with a circle of silky white hairs, which are longer than the flowers. The spikelets are usually single flowered; the sessile one fertile, the upper sometimes male only. The glumes are soft and chartaceous, the palets thin and transparent, and awnless.

The most striking differences between the two genera, are in the size and consistence of the flowering organs, in the manner of branching of the panicle, and in the presence in Saccharum of the long hairs at the base of the spikelets.

The above will suffice to settle a question, which could not have arisen but that a recent writer, who, by some, might be assumed to speak with authority, has in his writings confounded the sorghums with sugar-cane, while he places a single variety of sorghum apparently in a genus by itself.

The Agricultural Character of Sorghum.

Under this head the Committee of the National Academy of Sciences say in their report:

The cultivated varieties of sorghum, considered botanically, are cereals. They belong more especially to that very small group of cereal species which have been cultivated from the dawn of history, and have developed along with our civilization. During ages of culture they have so changed under the hand of man, that we are ignorant as to their native countries, and know not what their original wild progenitors were. Their descendants now exist in a vast number of varieties, which differ so greatly among themselves, that neither scientific botanists nor practical cultivators are agreed as to what are true species, and what mere varieties which have arisen in cultivation.

The cultivated varieties of sorghum have been placed in the genera *Holcus*, *Andropogon*, and *Sorghum*, by different botanists—the latter being the name now accepted.

A generation ago, botanists grouped the numerous cultivated varieties into a considerable number of distinct species, without agreement as to how many: five or six were generally believed to exist. Certain varieties of durra, with the grain in a somewhat loose panicle, and which were more especially cultivated in Asia and in southern Europe, were classed as one species called *Sorghum* (*Holcus* or *Andropogon*) *vulgare;* the varieties with the grain in a densely contracted panicle, grown more largely in Africa, and known as Guinea corn, Egyptian durra, Moorish millet, etc., were grouped into another species called *S. cernuum ;* the variety best known as chocolate corn was the *S. bicolor ;* broom corn, and all the sugar producing kinds, were classed together as *S. saccharatum;* and other specific names were applied to smaller groups of these varieties.

But the investigations of modern science have gradually led to the belief, that all the numerous varieties once classed in the several species above enumerated had a common origin and constitute but a single species, to which the old name *Sorghum vulgare* is now applied.

This is now the belief of the most eminent botanists of the world. Some even go further, and believe that *all* the cultivated varieties of the genus, including the spiked millets (*Sorghum* (*Holcus*) *spicatum*), are the descendants of a single original parental species.

These conclusions have a most important bearing upon the subject of this special investigation.

It is a law of nature, that the longer a species is cultivated and the wider its cultivation extends, the more easily it changes into new varieties, and the wider the differences between the varieties become. Some species, however, have a

much greater capacity for variation than others, and *Sorghum vulgare* stands pre-eminent among the useful plants for this character.

The usefulness of any agricultural species is intimately correlated with its capacity for variation in cultivation, for this means capacity for the improvement of varieties by the only means known to cultivators by which such improvements may be effected. It also means capacity for adaptation to varied conditions of soil, climate, and natural surroundings, and, furthermore, adaptation to various methods of culture, and to various uses. It is a sort of plasticity which allows the species to be molded in the hands of the intelligent cultivator.

This species (Sorghum vulgare) has varied more widely under cultivation than any other cereal, unless it be Indian corn. The varieties differ in all their characters—in height, fruitfulness, habit of growth, grain, stalk, leaf, panicle, chemical composition, preference of soil, climate, and exposure; and so on, to all the differences in which species themselves differ. Its cultivation has extended to most of the warm, and many of the temperate, climates of the globe, and it has adapted itself to the varied uses and more varied agricultural methods of nearly all the civilized races of mankind.

The agricultural success of any plant in a country depends, in part, upon its fitness to the soil and climate, and in part to a variety of other conditions, one of which is, that it must fill some place in the agriculture of that country better than the other species competing with it. Sentiment and local customs are also factors, but which have less force in this country than in others.

Durra, Guinea corn, broom corn, and, probably, also chocolate corn, were introduced into this country in colonial times. During the days of more imperfect tools and machinery, and of difficult transportation, all our agricultural crops were, of necessity, grown upon a much smaller scale than now; and, on most farms, a greater variety of crops were grown than now. Most, if not all, the agricultural plants of the Old World were tried here, and many had a wide and sparse cultivation until well into the present century, and then disappeared under the new conditions of our agriculture. The cultivation of others became specialized. Varieties of this species may be found in both these categories. Durra and Guinea corn were both widely introduced, and they lingered in cultivation until crowded out by Indian corn. They were dropped just as many other minor crops were: they did not fill a place in our modern agriculture so well as some other species did, and now are only found in regions where Indian corn does not grow so well, particularly in the states which border on Mexico. Chocolate corn (the old S. bicolor) was cultivated here and there as a poor substitute for coffee; but, under the changed conditions of things, it has entirely disappeared from our fields and gardens, crowded out by imported and better coffee. Broom corn, also introduced in colonial times, was widely cultivated: forty years ago, very many persons grew enough for their own use or for local sale. It supplied a certain want better than any thing else, consequently, it could not be crowded out; but, under the conditions of modern agriculture, its cultivation has become specialized and concentrated in fewer localities, in some of which it has assumed an importance found nowhere else in the world. It has been greatly improved, and the cultivation of American varieties has now extended to the Old World.

About thirty years ago, the sugar yielding sorghum was introduced. Filling

a certain place on our farms better than any other plant previously tried, it spread in cultivation with a rapidity no other agricultural plant ever did before in this or any other country, and is the only one adapted to a wide region introduced into the United States since colonial times which has become of sufficient importance to be enumerated in the census. It has become the "sorghum" of common language, and its cultivation has extended the whole length and breadth of the country.

Its adaptation to our soil and climate is abundantly demonstrated, and its capacity for improvement also thoroughly proved. The Department of Agriculture has already examined more than forty varieties, some of which have originated in this country. We have, now, varieties with very unlike characters: some mature in eighty days, others require twice as long a time, and one variety has become, in a sense, perennial—a fact not true of any other cereal species grown in the country. They vary in habit of growth and in sugar content; the two extremes have been developed here—the one as rich as Louisiana sugar-cane, the other, the broom corn, so poor in sugar.

Belonging to such a plastic species, with such adaptation to a wide range of soil and climate, with such capacity for modification and improvement, already in such wide cultivation, and promising to meet such a definite want in our agricultural production, it is certain that, in obedience to natural laws, some of the existing varieties may be greatly improved, and that new ones may be made, some of which will better serve the ends we are now seeking than any varieties we now have. No efforts have yet been made to increase the sugar content by systematic, intelligent, and long continued selection. In the light of the successful results of experiment in this direction with sugar beets, and with the abundant experience we have with other species as to other results attained by such processes, we have much to hope as to improvement in this character with a species which has been so variously molded to the uses of man.

Agriculture, however intelligently pursued, is more of an art than a science. Hence, the ultimate profitableness of any agricultural crop introduced into a region new to it, can only be determined by actual trial through a series of years. The nature of the economical problem is such that science can not predict the result. It can, however, render great aid in making success more probable, and in hastening it where it otherwise might be much delayed. It can suggest means and methods, can indicate promising directions for experiment, can aid in foreseeing and overcoming many difficulties, suggest remedies for mishaps, and, in a multitude of ways, aid in solving the practical problem. This is especially true when the crop is to be manufactured into a commercial product, and emphatically so in the production of sugar, the whole economical aspects of which have been changed by the aid of modern science.

No agricultural species can be cultivated profitably every-where within its range of actual growth, and it is yet to be demonstrated where the best regions are for the most profitable growth of sorghum. This is only partly an agricultural problem; it is as intimately related to the question of winning the sugar in the best form and at the least expense. For the solution of the latter, scientific work is needed. It can ultimately be done in the sugar-house; it may be more quickly done, and with vastly greater economy, if this be aided by the scientific laboratory. The profitable production of sugar from cane, as now pursued in Louisiana, and from beets, as pursued in Europe, was achieved only

by such aid. The methods of extracting sugar from these two great sources are very unlike, and each was developed along with scientific investigation instituted for each special plant. Sorghum still needs this. The work so nobly begun and successfully pursued by the Agricultural Department, is still incomplete and unfinished. To use an agricultural simile, the crop has been sown, but the harvest has not been reaped.

Agriculturally, the sorghum question is solved so far as it can be, until science now does her share. That the crop may be widely and economically grown, containing a satisfactory amount of cane sugar, is sufficiently proved. All the problem remaining unsolved relates to the extraction of sugar. In view of the magnitude of the interests involved, the results already obtained, and the wide attention the matter is now receiving, we feel that there are most encouraging indications of practical success.

INTRODUCTION OF SORGHUM INTO THE UNITED STATES.

In 1850, M. de Montigny, the French consul at Shanghai, China, sent to the Geographical Society of Paris a lot of plants and seeds from China, and among them sorghum seed grown upon the island of Tsung-ming, at the mouth of the Yang-tse-kiang river.

It is said that but one seed germinated, and that from the single head 800 seeds were obtained, which were bought by the firm of Vilmorin, Andrieux & Co., of Paris, at one franc each.

In 1853, Wm. R. Prince, of Flushing, Long Island, N. Y., imported from France the black seed variety of Chinese sorghum into the United States of America, and in 1854 a few pounds of this seed was distributed.

In 1855, a large hogshead of the seed was disposed of in small quantities throughout the country.

The first lot of sorghum seed sent out by the Agricultural Department at Washingtom was in 1856, and, about this same time, Orange Judd distributed to the subscribers of the American Agriculturist 25,000 packages of this seed.

In 1857, Leonard Wray, an English merchant, brought from Natal, South Africa, 16 varieties of sorghum seed, which were sent to South Carolina and Georgia and grown there.

To these African varieties the general name Imphees was given, while to the variety from China the name Chinese Sugar-Cane was given.

In 1840, M. d'Abadie sent to the Museum at Paris the seed of 30 kinds of sorghum from Abyssinia, and it is said of several of these, that the stalks had a sweet juice. But whether any of these seeds were planted, does not appear to be a matter of record, and the cultivation of sorghum during these later years appears to

have begun with the introduction of the China variety by M. de Montigny, in 1850.

Although throughout France and in Algeria the cultivation of sorghum rapidly spread, and many experiments were undertaken in the production of sugar from this plant, the new and growing beet sugar industry resulted in the abandonment of all efforts with sorghum, and it has been mainly in the United States that sorghum has been grown as a sugar producing plant during the last quarter of a century. Even here the crop has been chiefly used in the production of syrup, sugar having been only an accident of manufacture rather than the result of intelligent efforts for its production.

For several centuries, however, before the importations of M. de Montigny, sorghum had been extensively grown in Europe; not, indeed, as a sugar plant, although, so early as 1776, Pietro Arduini, of Florence, had succeeded in making sorghum sugar. He says, that the seed of the sorghum he experimented with was of a clear brown color.

In 1859, E. T. Teas, of Dunreith, Ind., reports to have imported from Vilmorin, Andrieux & Co., of Paris, a few pounds of Chinese cane seed, and that in this lot of seed, upon planting, he found a single plant, the seed of which had thoroughly ripened before the rest of the plants were in full bloom. The seed from this plant was carefully preserved, and is said to be the source of the Minnesota Early Amber, so named since it was very early, gave an amber colored syrup, and has been grown extensively in Minnesota of late years.

On the other hand, Mr. Leonard Wray at once recognized this so-called Early Amber, from the wood-cuts of the ripened panicle, as one of the 16 varietes of Imphees which he introduced in 1854, and he says the name is Boom-vwa-na.

In this connection, it will be interesting to know the names and descriptions of the several varieties which were introduced by Mr. Wray, which were as follows:

Vim-bis-chu-a-pa.—This is the largest and tallest of the whole; full of juice, very sweet; requiring from four to five months to come to maturity; grows to a height of ten to fifteen feet; from one and a half to two inches in diameter at the lower end; usually cracks or splits as it ripens; juice contains fourteen per cent of sugar; seed head large and beautiful, twelve to eighteen inches in length; plump seeds, sandy color, strongly held by a sheath, which partially envelops them.

E-a-na-moo-dee.—Next in size, and very similar in habit and value;

not as coarse, softer, and more juicy; fourteen per cent of sugar in juice; seed heads large, stiff, erect; seeds round, plump, of a clear yellow color; ripens two weeks earlier than last variety.

E-en-gha.—A fine, tall kind, from ten to twelve feet high, more slender than either of the foregoing, exceedingly graceful in appearance, ripens in four months; fourteen per cent of sugar in juice; seed head large, and very pretty; seed upon long, slender footstalks, which are bent down by weight of seed, forming a graceful drooping; seeds a dull yellow color, rather long and flat.

Nee-a-za-na.—Held, by the Zulu Kaffirs, to be the sweetest of all the Imphees; ripens in about three months; stalks soft, and more abounding in juice than any; fifteen per cent of sugar; small size, tillers greatly, having sometimes fifteen stalks to one root; juice mucilaginous, and abounding more in fecula than some other varieties; seed heads very bushy and bunchy when ripe; seeds round, large, and plump.

Boom-vwa-na.—Most excellent and valuable variety; juice never contains less than fifteen per cent of sugar; resembles the E-en-gha, but stalks brighter and more slender; stalks have a pinkish tint, and seed cases have pink and purple hue, mixed with a yellow ground; short, stiff footstalks; tillers very much, giving ten to twenty stalks for one root, which seldom weigh more than one pound each; makes beautiful sugar; reaches perfection in three to three and a half months.

Oom-see-a-na.—Distinguished by the purple or black appearance of its seed heads, the sheath, or seed cases, being of this color, and not the seed itself; seed head stiff, erect; short, strong footstalks; seed large, round, and full; growth and goodness of juice very similar to the Boom-vwa-na; stalks small, numerous.

Shla-goo-va.—Slightly inferior to the three last mentioned; ripens in three and a half months; tall, good sized plants; chief distinction, exceeding beauty and elegance of seed head; footstalk extremely long, drooping gracefully; seed cases, or sheaths, vary in color from a delicate pink to red, and from a light to a very dark purple, but each color is very bright and glistening.

Shla-goon-dee.—Sweet and good; under favorable conditions, produces fine sized stalks; seed heads very stiff, erect; seed vessels compact and very close; usually requires three and a half months to reach maturity.

Zim-moo-ma-na.—Likewise a sweet and good variety; seed heads upright, compact, and fine; seeds plump, very numerous.

E-both-la, Boo-ee-a-na, Koom-ba-na, See-en-gla, Zim-ba-za-na, E-thlo-sa.—These last six are merely mentioned by Mr. Wray, with the re-

mark, that they "form the remainder of fifteen varieties, each differing slightly from the others in saccharine qualities, as well as appearance; but still easily distinguished from each other by any one who has studied them."

J. H. Smith, of Quincy, Ill., who, in 1862, reports the results of his investigations upon sorghum, says:

Of the Chinese cane, we have known but one description, as before stated. We have cultivated six different kinds of the African canes.

And he enumerates six of those names already given.

The following letter from Mr. Leonard Wray, is especially interesting in connection with this discussion of the Imphees:

PERAK, via PENANG, *September 7th*, 1882.

To the Commissioner of Agriculture, Washington, U. S.

DEAR SIR: I am pleased, beyond measure, to find that the United States Government has *at last* awakened to the great value of the "imphee varieties," which I introduced into your country; and has taken the most certain course to verify, by scientific tests, the *truth* of my printed statements respecting them, published in English, and also in French, in 1854, copies of which I gave to Mr. D. J. Browne, of the Patent Office, in Washington.

You will find the contents of this, my pamphlet, in a little book by H. S. Olcott, published by Moore, of Fulton street, New York, in 1857; and if you do me the honor to read that, you will, I am sure, fairly acknowledge, that every statement I therein made is *strictly* proved by the valuable results of the able men whom you selected to conduct your experiments. I must, however, mention that the *last chapter* of my pamplet—viz, that on the manufacture of the imphee juice into sugar—is omitted in Olcott's little book.

It is most gratifying to see the "*thorough*" manner in which your Department has gone into, and decided these important questions.

I first became acquainted with these plants in March, 1851 (thirty and one-half years ago), just after my arrival in Natal, South Africa; and, in 1854, I grew them in several parts of France, in England, Spain, Italy, and in various other places, so that I may claim to know their merits; and I *now* say, that all I said and wrote about them at that time, I am fully prepared to stand by, and substantiate the truth of.

In fact, your admirable Department has, in its recent scientific demonstrations, abundantly and authoritatively confirmed my facts, and thereby rendered an inestimable service to your country, and to other countries also. I hope and trust you will continue it.

Looking at the beautiful plates in your reports, I can not but express my admiration, and, at the same time, my astonishment, at the very remarkable *constancy* of the "types" maintained by the different sorts of imphee shown. For instance, I may mention Plate 1, facing page 8, in Special Report, 33. This is there called "Imphee," "Liberian" and "Sumac;" but I distinctly recognize it as my "Koom-ba-na," one of the very sweetest and best I had. (I inclose you some *very old* seed.)

Plates 2, 3, and 4, are my Neeazana, and its sports.

Plate 5 is my En-ya-ma, which I see figures as "White Mammoth." I inclose some of my old seeds of it.

Plate 7 is my Oom-see-a-na.

Plate 8 seems to me to be the "Chinese sorgho."

Plate 9 is an Oom-see-a-na kind (no doubt a "sport").

Plate 10 is undoubtedly my "Vim-bis-chu-a-pa," which, to please General Hammond, I nicknamed Sorgho Ka-bai (or Sorgho Brother). Some grew to six pounds weight when "topped," and I had the head of one such until about nine months ago, when I unluckily threw it away (it was twenty inches long). I see you call it by the names of Honduras, Honey, Mastodon, etc.

Plate 11 seems to be no other than my Boom-vwa-na, one of my special favorites. Please see the description in my little pamphlet (in Olcott's book, 1857), and I think you will not long be in any doubt about its origin, bogus stories notwithstanding.

Plates 12 and 13 are both my imphees, and I had some growing here twelve months ago; but the seed unfortunately got spoiled.

The seed you were kind enough to favor me with, I have sown, and had sown by my friends here; and mine are now eight inches high, being only sixteen days' growth. I may mention that I soaked my seed in a strong solution of sugar, with a little *salt, camphor, and soap-suds*, for twenty hours, and I think they are growing much more vigorously than those *not* so treated. I shall continue to watch them.

Pray, do not think me ungrateful, when I say that I felt disappointed in not finding any "*Minnesota Early Amber*," nor any "Oomseeana," among the seed you sent me; and I trust you will forgive me, if I trespass so far on your kindness, to beg that you will be so good as to send me some of those two kinds, also as "*White Mammoth*" and "*Sumac*," all of which I particularly wish to have. Even one hundred or two hundred seeds of *each of these four sorts* will be ample for me to propagate from; and these might come in a letter direct to me here (and not by Singapore). In such case, the correct address is, "Perak, via Pinang, straits of Malacca," nothing more.

I need not say, also, how thankful I shall feel for any of your instructive reports, or other information you may be kind enough to bestow upon me.

I will, by no means, neglect to send you a goodly assortment of such seeds as I think you will be glad to have, as soon as they are ready. With many excuses for so troubling you, I beg to subscribe myself, dear sir,

Yours, very faithfully,

LEONARD WRAY.

In explanation of the above letter, it is necessary to say, that the plates referred to by Mr. Wray, were of the ripened panicles, or seed heads, of several varieties which had been grown at the Department of Agriculture at Washington, from seed received from different parts of the United States. Not unfrequently the same variety came under several different names: *e. g.*, Plate 1 was received under the names of Liberian, Imphee, Sumac, Chinese. Mr. Wray recognizes it as his Koom-ba-na. Plates 2, 3, 4, were from seed named, respectively, Neeazana, Wolf Tail, Gray Top. They are, without doubt, very closely

allied, if not identical, varieties. Mr. Wray recognizes them as his original Neeāzānā and its "sports."

Plate 5 was received from Western Missouri under the name of "White Mammoth." Mr. Wray recognized it as his En-yā-mā.

This name does not appear in his list already given, but it will be remembered that he is reported to have introduced *sixteen* varieties, and only *fifteen* are mentioned in his list. Besides this, "White Mammoth" is the most characteristic of all the varieties grown in this country, and can not possibly be confounded with any other. The seed is almost as white as rice, and the glumes are quite black.

It is especially interesting, also, that this was one of the two varieties of which Mr. Wray sent specimens of his *old* seed, and both specimens received from him were at once recognized as the identical ones which he declared them to be from the plates, viz.: Liberian (Koomba-na) and White Mammoth (En-yā-mā).

Plate 7 was grown as Oom-see-ā-nā, and such Mr. Wray declares it to be.

Plate 8 was grown from seed received from Hon. D. Wyatt Aiken, of South Carolina, and by him called "Black Top." Mr. Wray thinks it the original "Chinese Sorgo."

Plate 9 Mr. Wray pronounces an Oom-see-ā-nā sport. It is "Link's Hybrid," which Mr. Link, of Greeneville, Tenn., found in a field of "Honduras" sorghum.

Plate 10 is from seed which has come under the names Honduras, Mastodon, Honey Top, Texas Cane, Honey Cane, and Sprangle Top. Mr. Wray is positive that it is his old Vim-bis-chu-a-pa.

Plate 11 is the Early Amber. Mr. Wray's Boom-vwa-na.

Plates 12 and 13, Goose Neck and White Liberian, respectively, he also recognizes as among those varieties he imported. The great importance of this matter will be discussed in another place, but it is remarkable that these varieties should have so persistently retained their characteristics during over 30 years of continuous cultivation.

Hybridization of Sorghum.

The letter from Mr. Wray, and these reports from Natal, have much value, since they throw more light upon a matter of very great practical importance, and fully confirm the experience of the last five years at the Department of Agriculture at Washington.

Mr. Wray writes, that he is "astonished at the very remarkable constancy maintained by the several varieties" which he had introduced a third of a century before. It certainly is remarkable that Mr.

Wray should be able, even from plates, which fail to represent many of the marked peculiarities of the different varieties, to have at once recognized almost every one as among those introduced by him.

Perhaps nothing has been more generally believed, than that the greatest care was necessary to avoid the hybridization of the different sorghums.

At least a score of so-called hybrids have been received from one section and another of the country; and generally, along with the statement as to the desirable qualities of this new variety, the information is given that a *little seed* may be had at quite an advance over the price of common varieties.

It is reported, that, owing to the marked success which attended the production of sugar from sorghum at Rio Grande (near Cape May), New Jersey, the seed obtained was by certain thrifty farmers of that vicinity, sold under the name of "Cape May Hybrid," although it was no other than the common Early Amber variety.

It is probable, that, in the hands of an expert hybridist, there may be originated many new varieties, and possibly those surpassing in excellence any now known; but, at present, the so-called "hybrids" have not resulted in any such way, and, so far as they really exist, are only accidental.

During the past five years there have been cultivated in Washington, in all, at least 100 varieties, and upon the same plat of ground. These varieties were grown in rows, separated from each other only three feet, and, although it is possible that *crosses* have taken place, and remained unobserved, it is certain that no evidence has been seen of such fact: and this is the more remarkable, since, day by day, throughout the season, the different varieties were subject to careful observation.

As has been said, those specimens of seed received from foreign countries, have been found to contain generally several varieties under one name, differing very widely among themselves, and giving evidence of an admixture, in the samples received, of several distinct varieties.

No such result has ever been observed in the samples of seed received from various sources in the United States—since generally ripened panicles have been sent to the Department instead of the cleaned seed—and in no case was it found that two distinct kinds of seed were present upon the same panicle. This result is entirely at variance with the universal experience in growing different varieties of maize in the same vicinity; and in this regard the two plants, which, in many respects are similar, could hardly be more unlike.

It would appear incredible, if this tendency to "cross" or "sport"

was in any degree marked, that these many varieties could have been grown by our farmers for thirty years, and have so entirely maintained their identity. In regard to the "White Mammoth," the En-yā-mā, of Mr. Wray, the only specimen received at Washington came from Western Missouri. Of all the varieties, none is more marked than this one; and yet, grown year after year beside a score of varieties quite distinct, it has steadily maintained its integrity, not a seed of any other variety is found upon its panicles; nor has it, so far as careful observation extends, in any way affected its neighboring varieties. The contrast with maize could not be more noticeable. Under similar conditions, hardly an ear of maize in the field would be found uniform as to its seed.

In this connection, a portion of a letter from Ephraim Link, of Greenville, Tenn., one of our most intelligent cultivators of sorghum, will be of interest.

It accounts for the origin of the so-called "Link's Hybrid," one of our most valuable varieties of sorghum; but it will be seen, that there is not the slightest evidence of hybridization given. Indeed, under the circumstances, it appears impossible that hybridization could have taken place, since the single original head of "Link's Hybrid" was found in a field of Honduras. It would seem most likely that, unless this was simply a sport, remarkable for its persistence in retaining its valuable peculiarities, it may have been one of the original Imphees introduced by Mr. Wray, and which, but for the careful observation of Mr. Link, might have been quite lost. It is remarkable, that, of the varieties introduced by Mr. Wray, he is now able to at once recognize so many among those cultivated in America; while, of the large number recently received by the author from Natál, not one is to be confounded with either of those hitherto examined.

From letter of Ephraim Link.

Perhaps six years since, I procured my first Honduras seed from Mississippi, and readily found it much superior to any of the varieties I had before cultivated, and discarded all others in the endeavor to prevent any hybridization. It remained seemingly pure and fully satisfactory for several years, during which time I furnished the Department at Washington seed for distribution to the amount, in three years, of 50 bushels or more. In my crop of 1879, I saw a good many heads indicating a mixture, for which I could not account, and which I had been so careful to avoid, unless the contamination occurred the first year, when another variety grew a little distance off. If so, the contaminating principle lay dormant three years and had developed only that year. I sent to a friend in Texas for an entire renewal of seed for the planting of the spring of 1880, and found that, and the crop of last year, to be very pure, and to ripen two or three weeks sooner than the same variety before grown. Here

also is a locked mystery I fail to understand. Also, four years ago I found a head—a clear sprout in the Honduras—entirely different in appearance from it, propagated it, and found its yield and richness in juice second to no other, and its syrup freer from the sorghum flavor than any I ever made. I sent General Le Duc a specimen of the syrup and seed, and he ordered all the seed I had, about 14 bushels. In his report of the analysis of varieties, he calls it "Link's Hybrid." It grows to good size, stands well, ripens before the Honduras, and I predict for it a high place among varieties.

EPHRAIM LINK.

GREENVILLE, TENN.

CHAPTER IV.

(*a.*) Varieties of sorghum cultivated in the United States.
(*b.*) Signification of the names of the varieties of sorghum.
(*c.*) Table for identification of varieties.
(*d.*) Comparison of sorghums from different countries.

VARIETIES OF SORGHUM CULTIVATED IN THE UNITED STATES.

DURING the seasons of 1879, '80, '81, and '82, there were received, at the Department of Agriculture, the seed of very many distinct varieties of sorghum, from different parts of the country; and these have been cultivated, and subjected to a careful examination, during the entire period of their growth, for the purpose of determining their actual and relative value for sugar production. In the case of many of them, cultivation and examination were continued during the four years; and since the several varieties of seed were planted on the same plat of ground, and upon the same day, and were subject to the same climatic conditions during growth, their relative value, under the conditions of climate prevailing at Washington, is established. What these conditions of soil and climate were, will be presented in another chapter.

It often happened that the same variety of sorghum seed was received from several localities, under as many different names; as, for example, the same seed came as Chinese, Liberian, Oomseeana, Sumac, Imphee; and, it is interesting to observe, that its origin was, by one referred to China, and by another to Liberia, West Africa; although I find no record of any sorghum seed having been received from any other African locality than Natal, in South Africa.

Many other samples of seed were obtained, which, upon being cultivated, produced plants very closely resembling each other, if, indeed, they were not identical. It is quite probable that the slight differences existing between the so-called Honduras, Mastodon, Honey Top, Honey Cane, Sprangle Top, and Texas Cane, are the result of variation produced by the different climates and soils in which these canes have been grown during the past thirty-four years, since their introduction by Mr. Wray.

The same appears true of those varieties known as the Early Orange, Orange, Wolf Tail, Gray Top, each of which bears a close resemblance to the Neeazana, another of Mr. Wray's original importations. So, too,

the Early Amber, Early Golden, Golden Syrup, and at least three others, which have been sent as "new varieties" without name, are so nearly alike as to trouble one to distinguish them; and these are recognized, also, by Mr. Wray, as identical with, or but slight variations from, his original Boom-vwa-na.

Relative Lengths and Weights of the different Varieties of Sorghum.

In the following table will be found the average length of the several varieties of sorghum, as grown upon the experimental plat of the Department grounds; the average weight of the entire plant; of the stalk topped and stripped of its leaves, and ready for the mill; as, also, the number of stalks of each variety upon which such averages are based.

This table will enable any one to determine the relative amount of either variety which may be grown upon an acre, since these several varieties were grown from seed planted the same day, and upon a plat of ground which insured practically uniform conditions in every respect, since the culture of all varieties was the same.

It will be observed that the average loss, by stripping and topping, is, in the case of the sorghums, 24.6 per cent, and of the maize 38.4 per cent.

RELATIVE LENGTHS AND WEIGHTS OF THE DIFFERENT VARIETIES OF SORGHUM.

Name.	Source of Seed.	No. Stalks.	Length.	Total Weight.	Stripped Weight.
			Feet.	*Lbs.*	*Lbs.*
Early Amber	D. Smith, Arlington, Va	111	8 70	1 390	0.960
" "	Plant Seed Company, St. Louis, Mo	104	8 70	1 410	1.004
Early Golden	A. B. Swain, Elysian, Minn	98	8 70	1.370	1 001
Golden Syrup	W. H. Lytle, Yellow Springs, Ohio	101	8.50	1.370	1 001
White Liberian	Rush G. Leaming, Decatur, Neb	62	8.46	1.629	1 337
Early Amber	S. E. Evans, Monroe, Kan	54	8 54	1.317	0 979
Black Top Sorghum	D. W. Aiken, Cokesbury, S. C	48	7 48	1 409	0.961
African Sorghum	W. E. Parks, Carlisle, Ky	100	8.59	1 654	1 155
White Mammoth	Amos Carpenter, Carpenter's Store P. O., Mo	50	9 54	1.637	1 353
Oomseeana	Blymyer & Co., Cincinnati, Ohio	100	8 26	1 578	1.169
Regular Sorgho	Blymyer & Co., Cincinnati, Ohio	101	9.435	1 779	1.266
Hybrid	E. Link, Greeneville, Tenn	43	8 854	1.901	1 379
Sugar Cane	J. W. Barger, Lovilia, Iowa	51	7.326	1.261	0.893
Oomseeana Sorghum	D. W. Aiken, Cokesbury, S. C.	52	8.398	1.510	1.140
Neeazana	W. H. Lytle, Yellow Springs, Ohio	105	7.694	1.512	1 089
Goose Neck	P. P. Ramsey, Belgrade, Mo	94	9 057	1.738	1.255
Early Orange	I. A. Hedges, St. Louis, Mo	92	8 238	2.115	1.467
Neeazana	Blymyer & Co., Cincinnati, Ohio	104	7 547	1.450	1 047
New Variety	E. Link, Greeneville, Tenn	41	9 144	1.562	1.181
Chinese	D. Smith, Arlington, Va	93	7 95	1 722	1.225
Wolf Tail	E. Link, Greeneville, Tenn	34	8.06	1.449	1.277

Relative Lengths and Weights, etc.—Continued.

NAME.	SOURCE OF SEED.	No. Stalks.	Length.	Total Weight.	Stripped Weight.
			Feet.	*Lbs.*	*Lbs.*
Gray Top	H. C. Sealey, Columbia, Tenn	92	7.419	1 661	1 189
Liberian	Blymyer & Co., Cincinnati, Ohio	101	8.61	2 370	1 807
Liberian	W. H. Lytle, Yellow Springs, Ohio	99	8 29	2 154	1 803
Oomseeana	W. I. Mayes & Co., Sweet Water, Tenn	83	8.11	2 337	1 729
Sumac	W. Pope, Jones Switch, Ala	81	8.70	2 177	1 632
Mastodon	D. W. Aiken, Cokesbury, S. C	46	11.33	2 612	1 928
Imphee	D. W. Aiken, Cokesbury, S. C	41	8 84	2 057	1 543
New Variety	J. W. H. Salle, Strafford, Mo	73	8 33	1 786	1 200
Sumac	J. H. Wighton, Mount Olive, Ala	36	8.68	2 041	1 528
Honduras	Arsenal, Washington, D. C	82	10 09	1 633	1 269
Honey Cane	J. H. Clark, Pleasant Hill, La	84	11.35	2 771	2 289
Sprangle Top	W. Pope, Jones Switch, Ala	90	11.07	2 378	1 854
Honduras	E. Link, Greeneville, Tenn	62	11 60	2 54[illegible]	2 143
Honey Top or Texas	——, Brussels, Mo	97	11.48	2 517	2 181
Honduras	L. Brande, Mayersville, Texas	81	11.76	2 579	2 079
Sugar Cane	C. E. Miller, Effingham, Ill	120	6 82	1 089	0 731
Hybrid	J. C. Moore, San Diego, Cal	67	8 95	1 869	1 262
Sugar Cane	E. Link, Greeneville, Tenn	35	9 29	1 700	1 331
Bear Tail	Jacob Latshaw, Cedarville, Ill	42	8 06	1 383	1 055
Iowa Red Top	Jacob Latshaw, Cedarville, Ill	41	8 39	1 329	1 009
New Variety	F. W. Stump, Marshall, Ill	41	8 34	1 309	1 037
W. India Sugar Cane	D. C. Snow, Lamoile, Iowa	15	7 89	2 107	1.653
White African	John N. Barger, Lovilia, Iowa	33	7.75	1.434	1.045
Goose Neck	G N. Gibson, Shelbyville, Ky	31	8.19	1 852	1 335
White Imphee	John N. Barger, Lovilia, Iowa	35	7 50	1.309	0 911
Hybrid, No 4	Will N. Wallis, Collin County, Texas	40	8 79	1 410	1 065
Sugar Cane	John N. Barger, Lovilia, Iowa	21	6 65	1 324	0.971
New Variety	John N. Barger, Lovilia, Iowa	25	5 73	1 184	0 884
Min'sota Early Amber	Vilmorin, Paris	29	7 30	1 441	1.097
Holcus Saccharatus	Vilmorin, Paris	18	7 88	1.933	0 722
Holcus Sorghum	Vilmorin, Paris	28	7.69	1 036	0 746
Holcus Cernus, white	Vilmorin, Paris	22	8 26	1 855	1.245
Honey Cane	J. H. Clark, Pleasant Hill, La	14	10 23	2 193	1 765
New Variety	D. B. Bradford, Elizabeth City, N. C	15	......	...	1 250
Chinese Imphee	W. A. Sanders, Sanders, Cal	23	.....	..	1.128
New Variety	Richard Haswell, Armstrong Grove, Ia	23	..	....	1 040
Standard, No. 2	Isaac O. Harrell, Greeneville, Tenn	25	.. ..	..	1 488
New Variety	Hampden Sidney Coll, Va	23	...	..	0 800

In the above list, sixteen States are represented as furnishing seed; and four varieties were obtained from France, among which is our own Early Amber, which already appears to be grown there from seed imported from America. Although, some thirty years since, we obtained our Chinese varieties of sorghum from France, and having, at the present time, many of them extensively cultivated in the United States, nearly all, if not every variety, of these Chinese sorghums seem to have disappeared from France, since the large house of Vilmorin & Co. were unable to send even a single specimen.

The local names of the above mentioned varieties (as, for example, West India sugar-cane), must not be confounded with the real sugar-cane of Cuba and Louisiana; for the so-called sugar-canes, represented

by the above numbers, are only varieties of sorghum, a family of plants quite distinct from the true sugar-cane.

Varieties of Sorghum received from Africa, China, and India.

In 1881, the author received through President Angell, Minister to China, six varieties of sorghum seed, the names of which were as follows:

Hwong-mao-nien-liang—Yellow-cap-glutinous-millet.
San-sui-hoong-liang—Separated-headstalks-red-millet.
San-sui-pai-liang—Separated-headstalks-white-millet.
Er-chiu-hung-liang—Second-autumn-red-millet.
Ma-wei-nien-liang—Horse-tail-glutinous-millet.
Ta-min-hung-liang—Large-people's-red-millet.

Also, through W. T. Thiselton Dyer, Esq., Assistant Director of the Royal Gardens, Kew, England, thirteen varieties of sorghum seed from the Botanical Gardens at Natal, South Africa, and from the Gordon Memorial Mission of Natal; also, through Mr. Dyer, two varieties from Cawnpoor, India.

The names of these were as follows:

From Natal.

Undendebule.	Umgatubanda.
Ukubane.	Ubehlana.
Jyangentombi.	Ufatane.
Iyenga.	Unkunjana.
Ibohla.	Hlogonde.
Dindemuka.	Unhlokonde.
Uboyana.	

From India.

Black Sorgho.	Red Sorgho.

Upon planting these, it was found that very many more varieties could be distinguished than had been recognized by those sending the seed; and it was found that there were at least 14 instead of 6 of the Chinese, 26 instead of 13 of the African, and 3 instead of 2 of the Indian. This appears the more remarkable, since, in a letter from the Assistant Secretary for Native Affairs, J. Shepstone, Esq., of Natal, he says: "The natives that I have spoken to only know of six varieties of the 'Imfe.'"

Besides these specimens of seed, the author received from Wm. Keit, Esq., Director of the Royal Botanical Gardens at Natal, ripened panicles of the several varieties mentioned below, for the greater facility of identification:

Iyenga Imphee.	Dundemuka Imphee.
Ufatana Imphee.	Unkunyana Imphee.
Ubehlana Imphee.	Hlogonde Imphee.
Undendebule Imphee.	Umgatubanda Amabele.

Also from Dr. Dalzell, of the Gordon Memorial Mission, Natal, the following list of ripened panicles:

U-Dwe Imphee.	Dindemuka Imphee.
M-behlana Imphee.	Hlogonde Imphee.
Iyenga Imphee.	Ukabane Amabele.
U-fengkule Imphee.	Umquatubanda Amabele.
Ihlosa Imphee.	

The differences in the spelling, of what are obviously the same names in the several lists, is retained.

It will be observed that there are twelve varieties in the two lists of ripe panicles, and that four of the varieties in the list of seeds are not represented among the lists of panicles.

We have then sixteen named varieties received from Natal in these several lots, although the natives knew of only six, as was reported.

This is the exact number of varieties which Mr. Wray brought from Natal in 1854; but it is to be noticed, that of his list only four of his varieties, in name, bear any resemblance to those in the above lists, viz:

Iyenga, which may be his E-en-gha.
Ihlosa, which may be his E-thlo-sa.
Ibothla, which may be his E-both-la.
Hlogonde, which may be his Shla-goon-de.

Supposing the above four to be identical, it would seem that at least 28 named varieties have already been received from Natal.

The thirteen specimens of seed received were planted, and twenty-six varieties were observed among them, and not one resembled either of the numerous varieties grown in America the past thirty years, and which have been grown at the Department of Agriculture, in Washington. Either the effect of climate and cultivation has been such as to materially change the character of those varieties introduced by Mr. Wray, or else there must exist, under cultivation in South Africa, a much larger number of varieties than those already received from there. Since Mr. Wray so readily recognizes his old varieties from the plates published in the reports of the Department of Agriculture, it would hardly seem possible that any change has resulted; and the conclusion appears well founded, that these numerous varieties

have already, through centuries of cultivation in Africa, become permanently fixed in their character.

Besides the above foreign varieties, there have been grown, at the Department of Agriculture, at Washington, during the past five years, nominally, sixty distinct varieties of sorghum, from seed received from different parts of the country: and, at the present time, the author has in his possession full ripened panicles representing all these, as, also, each of the foreign varieties already mentioned, besides many specimens of seed from what purport to be new varieties, which have been sent in to be planted, in order that their comparative value for the purpose of syrup and sugar production might be determined. In the current news concerning this industry, mention is often made of other varieties, at least, under names new to the author, and it is, without doubt, true that there exists, at present, in the United States, at least one hundred varieties of sorghum, more or less distinct. There is little reason to doubt, that, should a careful examination be made in those sections which have already so abundantly supplied us with new varieties, the list might be very greatly extended. Indeed, when we remember that, so far as our knowledge extends, India is the original home of the sorghum, and that, for thousands of years, in all probability, it has been subjected to cultivation there, it seems more than probable that very many varieties now unknown to us, and, possibly, surpassing in value any we now possess, might be found there. More than twenty years ago, Mr. J. H. Smith, of Quincy, Ill., in an article upon sorghum, says, in reference to this very point: "Is there any way in which the Agricultural Department at Washington could spend money to better advantage, than in sending an experienced agent to the countries from which these canes have originated, for the purpose of obtaining all possible knowledge concerning these important accessions to the agriculture of our country?"

A distinction is made in the sorghums received from Natal, most of them being called Imphees: but two are called Amabele. Professor von Kloeden speaks of the native Kaffirs calling the fifteen varieties which they cultivate Imphi or Mabali; and he mentions Bali as the name under which the sorghum is grown in Egypt, where six varieties are cultivated.

I have not met with these names elsewhere in the literature of sorghum. But the use at Natal as a specific name is interesting, and it will be observed, in the plates showing the ripe panicles of these two varieties, that they are peculiar in having large, prominent seed; in fact, the Umgatubanda is remarkable for the size of its seed.

Analysis also shows the juice of these two varieties to be very infe-

rior in its content of sugar to the other African varieties, and comparatively of little value. From the above considerations, it would appear as though there existed very marked differences between these two groups of sorghums, not to be accounted for by cultivation, so far as we know.

In the Report of the Government Farms, Said á pet, Madras, India, Sept. 7th, 1882, mention is made of three varieties of sorghum as being there under cultivation experimentally: Black Cholum (Sorghum vulgare), Planter's Friend (Sorghum kaffrarium), Chinese Sugar-cane (Sorghum saccharatum). The last two were used in making syrup, and preference was given to the Planter's Friend for its greater saccharine value. Mention is also made of broom millet (a variety of sorghum), and of the Early Amber sorghum, from the United States of America; and it is reported that the syrup of the Early Amber crystallizes far more rapidly, and to a much more considerable extent, than the syrup of either Sorghum saccharatum or Sorghum kaffrarium. The refuse canes (bagasse), after crushing, are far more palatable to stock than refuse of sugar-cane; and, judging from its appearance and general character, the refuse sorghum must be far more digestible.

SIGNIFICATION OF THE NAMES OF THE VARIETIES OF SORGHUM.

It will be observed that in the names given to the different varieties of sorghum, there is a tendency on the part of those cultivating them to describe them by their physical peculiarities. Thus, we have the "Sprangle Top," which has a loose, waving seed head; the "Sumac," which in its close, compact panicle, resembles the seed head of our common Sumac, so well known to our farmers; the "Goose Neck," owing to the bent culm of this variety, a characteristic which is not uncommon with several other varieties.

So, too, in the Chinese names, we have the "Separated Head Stalks," red and white; the Horse Tail, etc.

Also, in the South African varieties, the same tendency appears in their names: as, for example, "Jyenga" means "loose headed, waving;" "Hlojonde" is "long headed," etc.

In this connection, the following letters will be found of interest, being in reply to letters of inquiry as to the significance of those names of the Imphees found current in sorghum literature, of which names a list was sent.

Two of the varieties of sorghum received from Natal, viz., Ukabane and Umgatubanda, are called Amabele, while the remainder are designated as Imphees.

The following letters were received through the kindness of Mr. Dyer, of the Royal Gardens, Kew, to whom a list of the Imphee names had been sent. The one is from the Assistant Secretary of Native Affairs at Natal, the other from the daughter of the late Bishop of Natal:

Secretary of Native Affairs to Colonial Secretary, Natal:

I can not give the meaning of the generic term, "Imfe," nor can I find natives that can do so. The natives that I have spoken to only know of six varieties of the "Imfe," of which I will give the names and derivations:

1st. "Iyenga"—Enticer—from its drooping or waving ear or head of corn.

2nd. Umbemba—Sprouts or shoots. This cane invariably having small shoots from each joint.

3rd. "Uzimumana"—The enwrapped—from the close adherence of the outer leaves to the cane.

4th. Umapofu—The yellow—from its yellow color.

5th. Ihlosa—The prominent—from its growing generally higher than other corn with which it is sown.

6th. Unfenkulu—The great Imfe—from its large size.

The names given in the list inclosed by you, are, I believe, repetitions obtained from different tribes, many having names according to the dialect spoken. The names are also badly spelt.

(Signed,) J. Shepstone,
Ass't Sec'y for Native Affairs.

Nos. 2, 3, and 4 of this list are new names, for they neither appear in the list of names of Mr. Wray's varieties, nor in that of the seeds and panicles received by me from Natal.

List of Imphees returned by Miss Colenso.

"Undendebule." Not recognized, but the word ukudendebuleka means "capable of being peeled straight down through the joints."

"Umkunyana." Not recognized, but the word should mean "rather hard."

"Unhlokonde," "Hlgonde," "Slagonda." The first means "long head;" the others are the same word misspelt.

"Ibohla" probably means "causing flatulence."

"Iyenga," "Eenga," "Engha." The first means "loose headed," "waving;" the others are the same word misspelt.

"Umnyani-mude—"with long flower stalks or head." The head in this variety is still longer than that of the "Unhlokonde.

"Boomvana," "Boom-vwana," Booena." The first means "small red" or "rather red;' the last two are misspelt.

"Uzimumana," "Limmoomana," "Zimmoomana." The first means "close," "thick headed." The last two names are misspelt.

"Hlakuva." Called so after the castor oil plant; the seeds being thought to look alike. A very small headed, short variety.

"Zimbazana." Called so after "Izimba," a variety of "Kaffir corn," because very like it. "Izimba" is used as grain in making beer. "Zimbazana" may be used so, also.

"Ihlosa"—"budding," "beginning to swell." A variety which looks young when already grown.

"Elwofla," "Ehahla." Not recognized, but evidently the same.

"Koombana," "Koombanna." Not recognized, but evidently the same.

"Ubayana," "Ukubane," "Ubehlane," "Jyangenbambi," "Dindemuka," "Ugabane," "Umgatubanda," "Oomseeana," "Neeazana," "Sangokahea," "Vimbischuapa." None of these names are recognized.

The following plates show the ripened panicles of several of the more characteristic varieties of sorghum—of those grown in the United States, and of those grown from seed received from South Africa, China, and India.

The labels attached to the engravings, which were made from photographs, were, in every case, two inches by one in actual size, so that the dimensions of each panicle may be readily ascertained by this scale of measurement.

The Black and Red sorgho, Plates I and II, are from Cawnpore, India; Plates III and IV are two varieties from Northern China; Plates V and VI are two of the new South African varieties, called Amabele; Plates VII, VIII, and IX, are of the new South African varieties, called Imphees; Plates X, XI, XII, XIII, XIV, XV, are of characteristic varieties grown during the past thirty years in the United States, being either the original varieties introduced by Mr. Wray, or varieties which have proceeded from them. It is possible that some of them may have had a Chinese origin, though they partake rather of the general African type.

The names given to these six American grown varieties, have been those names by which they have been generally known in this country, although, as has been remarked, the same variety has been received from several localities under different names; for example, the Liberian, Plate XII, has been received under the names Imphee, Chinese, Sumac, and Liberian.

The frontispiece represents a hill of the variety known as Honduras, which has also been received under the names Mastodon, Sprangle Top, Honey Top, Texas Cane, Honey Cane. It is possible that two or

three of the larger varieties introduced by Mr. Wray may be confounded under these several names, but, at the present, the identity of each has not been established. The compact heads of the African varieties is a marked feature; but that is not a characteristic of those which are valuable for sugar, since two of these, Plates V and VI, which are called Amabele, are practically worthless for sugar, although, like the other African varieties (Imphees), they have compact panicles or seed heads. The two varieties from Northern India have loose, waving heads, but are very valuable for sugar, as the analysis, page 101, will show. The presence of these two distinct classes from South Africa, with their wide difference in sugar content, is highly interesting, especially in view of their being recognized as belonging to distinct families. It will be seen that the per cent of sugar in the juice of the two Amabeles averages 4.90, while in the seventeen Imphee varieties it averages 11.82 per cent.

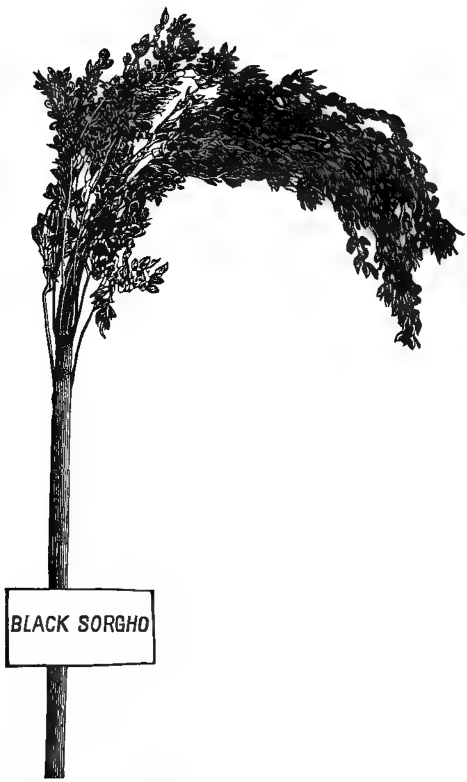


Plate I.

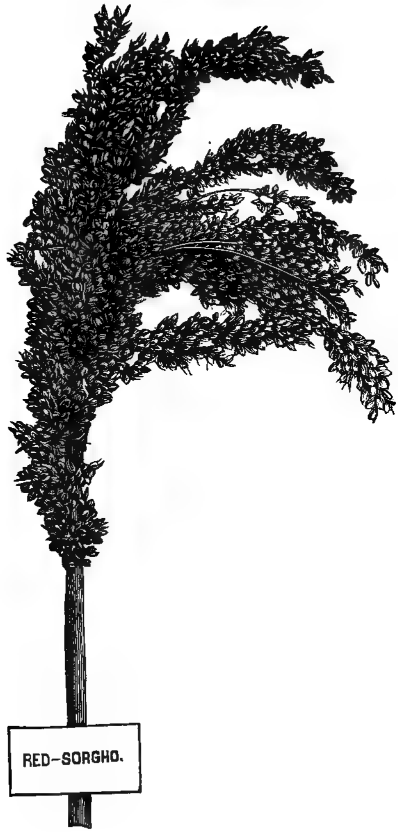


Plate II.

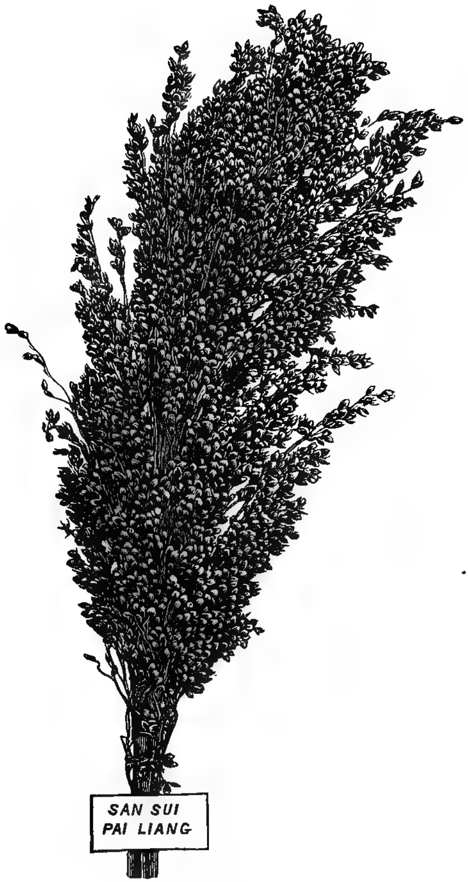


Plate III.

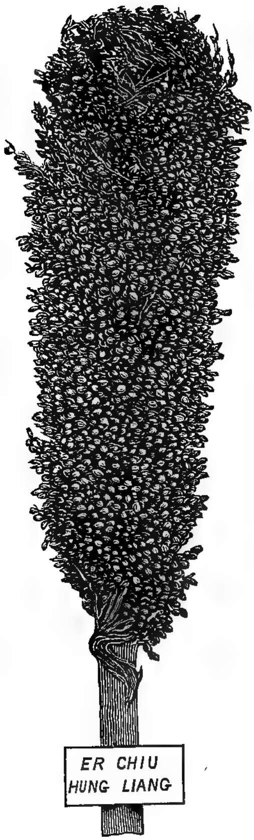


Plate IV.

Plate V.

Plate VI.

Plate VII.

Plate VIII.

Plate IX.

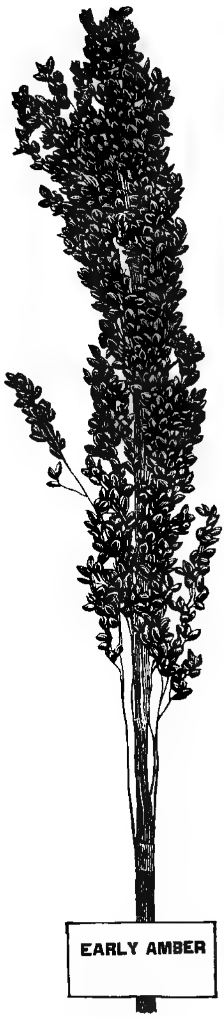


Plate X.

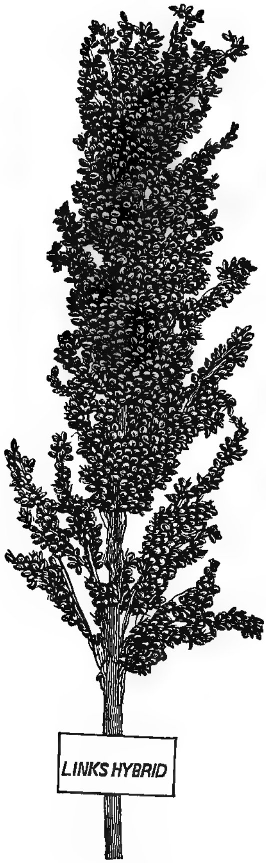


Plate XI.

Plate XII.

Plate XIII.

Plate XIV.

Plate XV.

SYNOPTICAL TABLE OF THE VARIETIES OF SORGHUM CULTIVATED AT THE DEPARTMENT OF AGRICULTURE DURING THE YEARS 1879–80–81–82.

The following table can not claim any great degree of botanical accuracy, as it has been worked out from single dry heads, and without a careful comparison of the varieties growing in the field. It is believed, however, that it will be of great assistance in aiding the practical farmer to distinguish, with the aid of the illustrations, whatever variety he may have under cultivation.

It is based upon a similar table prepared by Mr. F. Peck, and published in the Annual Report of the Department of Agriculture, 1865:

The Ripe Grain.

I. Longer than the glumes (husks).

(A.) Panicle or head dense.

1. Glumes black.

a. Inconspicuous.

Liberian, or *Imphee.*

Head short, 6 to 7 inches long, dense, cylindrical, obtuse; general color dark brown.

Glumes small, obtuse, black shining; outer one hairy on the margin.

Seed smallest of all varieties, round, obtuse, tapering to the base; hilum or point of attachment of a lighter color and prominent.

b. Conspicuous.

Seeds brown; effect of head black. (Grain at times hardly longer than the glumes.)

Oomseeana.

Head slender, erect, 8 to 9 inches long; branches closely appressed, but not dense.

Glumes black, pointed; outer one keeled, smooth and open.

Seed deep brown, and visible between the open glumes; plane convex, acute at both ends.

Black Top.

Head larger and broader than the preceding, blacker and more dense; seed lighter.

Bear Tail.

Denser head and longer glumes than in preceding, resembling in some respects a compacted Early Amber.

Iowa Red Top.

An Oomseeana cane, with large, prominent seeds and smaller glumes.

Seeds white.

White Mammoth.

Head very dense, expanding toward the flattened top.
Glumes shining black, prominent.
Seed white, large, flattened; hilum inconspicuous.

2. Glumes light-red brown.

Seeds white.

White African

Head slender, 7 to 8 inches long; branches closely compressed but not very dense.
Glumes large, light red, shining.
Seed large, white.
Seed yellowish brown.

Neeazana.

Head 5 to 8 inches long, dense, cylindrical.
Glumes pointed, somewhat hairy; outer one gray: inner one black, smaller, and inconspicuous.
Seed long, flat; hilum inconspicuous.
Synon. White Imphee, Early Orange.
New Variety (Salle), similar to Neeazana, but both glumes are at times light colored and hairy.

Wolf Tail.

Head 9 to 10 inches long, slender, dense.
Glumes almost white, shining, somewhat downy.
Seed shorter than in Neeazana, long, round; hilum slightly flattened.

Gray Top.

Head similar to Neeazana, but glumes brown, shining, obtuse, short.
Seed short, long, large, prominent, round; hilum only slightly flattened; distinguished by its brown glumes and the prominence of the large round seeds in the head.

3. Glumes gray.

Rice, or Egyptian Corn.

Head heavy, bending the culm, dense, obtuse, cylindrical.
Glumes gray, prominent, wooly, persistent.
Seed large, flat, white, round in outline, width greater than the length; prominent in the head, and easily shaken out.

(B.) Panicle not dense.

Glumes black.

Regular Sorgho.

Head loose, 10 to 12 inches long.
Glumes black, shining, open, displaying the seeds.
Seeds large, flat, obtuse.

Hybrid Sorghum.

Hybrid of E. Link.
Oomseeana of Blymyer.

New Variety of E. Link.

These are hybrids of the Liberian or Imphee varieties with the Honduras or Chinese varieties, and bear the characteristics of both races. Here, also, might be mentioned—

African of Parks, of Kentucky.

Hybrid of Moore.

II. Equal to the glumes.

(A.) Glumes closed, or nearly so.

Red, and palet awned.

Honduras.

Head 1 foot long, thin, loose, spreading, nodding.

Glumes reddish brown, shining, somewhat hairy, acute at both ends; inner one keeled.

Seed long, very acute at the base, obtuse at the apex; plane convex; hilum conspicuous, with a prominence at the base, and a round mark at the upper edge.

Synon. Mastodon, Honey Cane, Sprangle Top, Honey Top. These all vary slightly, so as to be distinguished in the field; but not, however, by description.

Deep chocolate palet, awned.

Hybrid of Wallis, Collin county, Texas.

Similar to the Honduras, except in the deep brown glumes and more compact head, showing its Imphee affinities.

(B.) Glumes open.

Under this head might be sought Regular Sorgho and Black Top, classed as having the grain longer than the glumes.

III. Shorter than the glumes.

(A.) Glumes black.

Culm erect.

Early Amber.

Head slender, erect; branches appressed, pointed, 9 to 10 inches long.

Glumes large, smooth, shining, acute at both ends, concealing the seed or open, flattened on both sides.

Seeds long, obtuse, light colored; hilum large, with a prominence in the center.

Synon. Early Golden, Golden Syrup.

Culm erect, or often bent with heavy heads.

Goose Neck.

Head inverted on the bent culm; somewhat loose, 8 inches long.

Glumes shining, downy at the tips, flattened.

Seeds smaller than Amber, long, acute at the base, obtuse at the apex, somewhat flattened.

(B.) Glumes purplish.

White Liberian.

Head slender, erect, or goose-necked; branches appressed, pointed.

Glumes large, smooth, shining, acute at both ends, often not covering the seed. Infertile ones often very prominent and purplish gray.

Seed large, long, and similar to the Amber, but hilum more prominent.

Synon. Sugar-cane (Barger).

COMPARISON OF SORGHUMS GROWN FROM SEED RECEIVED FROM CHINA, NATAL, INDIA, AND FROM THE UNITED STATES.

These several varieties were grown upon the same plot of ground, in Washington, D. C., in the year 1882, and the results obtained are, therefore, comparable.

The number of analyses made of each group, the average weight of stripped stalks, the percentage of juice expressed, and the average percentages of sucrose, solids not sucrose (including glucose), and available sugar, in the juices, are given, for several stages of development.

The poor quality of the Chinese varieties is seen in the light weight of the stalks, the small percentage of juice expressed (though the same mill was used in all the experiments recorded—a total of 984), and in the lower percentage of sucrose and available sugar.

It is, however, to be remembered, that these Chinese seeds were obtained from about Peking, while the original Chinese sorghum seed imported into France by M. de Montigny, according to Dr. Williams, was grown upon the island Tsung-ming, which lies at the mouth of the Yang-tse-kiang river, some 700 miles south of Peking. It is not improbable that this warmer region had developed a variety richer in sugar than those of Northern China, where, as Dr. Williams says, the uses of the plant for grain and fuel may have developed qualities, during the centuries of its cultivation, fitting it for such purposes, but at the expense of its sugar content.

Comparison of 14 Chinese sorghums, 26 African, 3 Indian, and 20 American:

Percentage of Sucrose in Juice.

	Chinese.	African.	Indian.	American.
Seed in milk	6.90	8.72	8.07	8.91
Seed in dough	8.23	9.49	10.36	11.53
Seed, hard	8.93	10.20	9.52	11.57
Sucker seed in milk	9.57	10.83	12.03	12.01
Sucker seed in dough	9.61	12.24	11.85	12.80
Average	8.65	10.30	10.37	11.36

Comparison in Weight of Stripped Stalks and Juice.

	Chinese.	African.	Indian.	American.
No. analyses	136	384	50	414
Weight, pounds	.85	1.58	1.13	1.14
Juice, per cent	43.29	60.80	61.19	60.13

Percentage of available Sugar in Juice.

	Chinese.	African.	Indian.	American.
Seed in milk	2.10	3.66	3.28	3.43
Seed in dough	2.83	4.64	5.97	6.42
Seed, hard	4.51	6.41	5.36	7.11
Sucker seed in milk	5.18	6.70	7.68	7.69
Sucker seed in dough	4.98	8.46	7.75	8.91
Average	3.92	5.97	6.01	6.71

Percentage of Solids not Sucrose (including Glucose) in Juice.

	Chinese.	African.	Indian.	American.
Seed in milk	4.80	5.06	4.79	5.48
Seed in dough	5.40	4.85	4.39	5.11
Seed, hard	4.42	3.79	4.16	4.46
Sucker seed in milk	4.39	4.13	4.35	4.32
Sucker seed in dough	4.63	3.78	4.10	3.89
Average	4.73	4.32	4.36	4.65

From the above tables, the general resemblance between the African, Indian, and American varieties is noticeable, as to their quality of juice and its amount; but, while the Indian and American varieties have about the same weight, the average of the African varieties is much greater—the proportion between the African, American, Indian, and Chinese, in weight, being as follows: 100 : 72 : 71 : 54.

It will be seen, also, that the average content of sugar is a little greater in the American varieties than in any of the others, and this result may be due to the effects of our climate during the thirty-three years of their cultivation in the United States; or, to the fact that some principle of selection has prevailed during their cultivation, since, as is well known, their value as sugar producing plants has been steadily kept in mind.

Whichever view is taken of the matter, the practical conclusion is most favorable, for it appears hardly probable, that, by chance, such varieties only were introduced at that early day as were the best for sugar. It would seem, then, possible that, by more intelligent and systematic selection and cultivation, we might be able to produce a variety heavier than any yet known, and with a higher content of sugar.

Similar results with other cultivated plants are, by no means, exceptional.

The following table gives the relative heights and weights of the average sorghums from China, Africa, India, and the United States; also, the average length and weight of the panicles.

Season of 1882.

	10 Chinese.	20 African.	3 Indian.	18 American.
Average height of stalk.......... feet.	9.6	8.4	8.3	9
" weight of stripped stalk....pounds.	.746	1.44	1.20	1.13
" " panicle..........ounces.	3.925	3.88	2.83	2.68
" length of " ....inches.	15.1	10.93	9.00	10.06

The following table presents in detail, for comparison, the analyses of the four classes of sorghums, all of which were grown side by side, in 1882, at Washington. Those analyses only are included which were made after the seed had become hard.

Average Results in 1882,

Number.	VARIETY.	No. of Analyses.	Wght. of Stripped Stalks, pounds.	Per ct. Juice Expressed.	Per ct. Glucose in Juice.
1..	Hoong Mao Nien Liang (*a*)	1	.61	36.82	2 28
2..	San Sui Hoong Liang (*a*)	13	.44	40.19	.71
	" " " " (*b*)	1	.75	32.45	2.37
3..	San Sui Pai Liang (*a*)	9	.79	40.66	.75
	" " " " (*b*)	13	.76	42.94	.84
4..	Er Chiu Hung Liang (*a*)	17	.58	38.68	.65
5..	Ma Wei Nien Liang	12	.68	39.54	.60
6..	Ta Min Hung Liang (*a*)	15	.65	38.70	.83
	" " " " (*b*)	1	.85	39 11	1.93
	" " " " (*c*)	1	1.35	46.66	1.10
7..	Undendebule	23	1.28	56.07	.83
8..	Uknbane (*a*)	15	1.31	59.27	1.18
	" (*b*)	9	.86	53.75	.35
9.	Jyangentombi (*a*)	5	1.05	58.23	.88
	" (*b*)	1	1 24	65.72	1.30
11..	Ibohla	4	1.45	66 21	2.49
12.	Dindemuka	24	1.28	60.82	1.01
13..	Uboyana	20	1.85	62 06	1.72
14..	Umgatubanda	7	1.68	60 35	.97
15..	Ubehlana (*a*)	14	1.71	62.80	1.24
	" (*b*)	2	2.25	61 58	1 61
16..	Ufatane (*a*)	22	1.47	57 89	1.51
	" (*b*)	7	1.34	60 90	.98
	" (*c*)	9	1.65	58.96	1.20
17..	Unkunjana (*a*)	15	1.43	62 89	1.96
	" (*b*)	10	1.72	62.73	1.71
	" (*c*)	11	1.58	60.57	1.28
18..	Hlogonde (*a*)	18	1.40	57.54	1.35
	" (*b*)	18	1.35	57.86	1.44
19..	Unhlokonde	4	.95	59.93	1.84
20..	White Imphee	13	1.05	62 08	1.34
21..	White African	15	1.38	56 79	1.28
22..	White Mammoth	8	1.46	62.69	1.23
23..	West India	17	1.25	58.93	2.38
24..	New Variety (Stump)	15	.95	57.03	1.24
25..	Early Amber	22	.80	56 53	1.15
26..	New Variety (H. S. Coll.)	21	.76	59 95	1.17
27..	Bear Tail	23	.97	57.03	1 85
28..	Iowa Red Top	2	1.12	64 82	1.58
29..	Red Sorgho	18	1.41	57.67	1.45
30..	Black Sorgho (*a*)	12	.92	61.54	.97
	" " (*b*)	1	1.28	65.75	1.15
31..	Link's Hybrid	8	1.64	60.43	.84
32..	Standard (Harrall)	18	1.51	55.56	.59
33..	Neeazana	26	.76	53.69	1.92
34..	Gray Top	21	.99	61.30	1.26
35..	White Liberian	54	.82	56.11	1.25
37..	New Variety (Link)	19	1.28	56.07	1.28
38..	New Variety (Haswell)	19	1.02	56.79	1.54
39..	Chinese Imphee	21	1.06	53.48	1.16
40..	New Variety (Bradford)	5	1.50	55.36	1.91

After Seed was Hard.

Per cent Sucrose in Juice.	Per cent Solids in Juice.	Per ct. Available Sugar in Juice.	Specific Gra., in Juice.	Per cent by Polarization.	Time from Planting to Seed Hard.	Weight of Panicle.	Length of Panicle.	Height of Plant.
9.63	2.87	4.48	1067	....	....	3½	14½	9.3
9.13	3.80	4 62	1060	8.12	81	3½	14½	9.3
6.25	2 97	.91	1053	....	....	3¼	13½	....
8 93	3.85	4 33	1060	8.15	97	4	16	9.6
9.45	3.94	4 67	1061	10.30	97	4	12½	9.6
9.79	3 84	5 30	1062	9.88	90	5½	13	9 4
8 27	4.63	3 04	1060	9.46	104	3¼	14	10.0
8 56	4 07	3 65	1055	8 69	117	4¼	15	9.6
9.64	1.95	5 76	1058	9.64	....	4	19	....
10 63	2 34	7 19	1061	10 96	....	4	19	....
13 64	3 29	9 52	1077	13.57	124	5½	13	9.6
11.98	2.78	8 02	1067	12 05	100	3½	14½	9.C
5.27	3.20	1 72	1039	5.33	116	4	13½	5.6
13.45	3 10	9.47	1074	13 41	116	2½	10½	8.6
6.49	2.31	2 88	1042	6.52	136	4¼	8½	7 0
9.77	2.37	4 91	1061	9.58	115	3¾	13½	11.4
11.05	2.54	7 50	1064	10 95	136	2½	8	8 0
11.16	2.51	6 93	1065	10.94	143	5½	11½	8 2
4.52	2 67	.88	1043	4.24	115	4½	8	7.0
11.82	2.71	7 87	1069	11.54	124	3	15½	9 0
12.57	2.03	8 94	1069	12.31	143	1	9	8 3
12 09	2.66	7 92	1069	11 75	124	3	10	8 10
13.59	3 07	9 54	1075	13.68	143	5½	8½	6 1
10 85	2 68	6.97	1073	....	143	5	11½	7.8
10.11	2.06	6 09	1062	9.32	143	2½	10½	9.2
9 86	2 67	5 48	1059	8 50	136	5	14	10 6
11 70	2.47	7 95	1066	11 52	143	4	[illegible]	7.5
12.44	2 81	8 28	1071	11 63	129	6	13	8.9
12 99	2.64	8.91	1070	12 22	129	3	7½	7.4
11 99	2.14	8.01	1065	10 58	115	3½	10	9.2
11.81	2.89	7 58	1069	12 01	107	3	8½	8.1
11.62	2.92	7.42	1068	11 17	115	4	10½	9.6
11 58	3.14	7.21	1067	12 02	115	3	[illegible]	10.3
11.34	2 61	6.35	1073	10 93	115	3	9	8.6
11.87	3 22	7.41	1067	12.01	100	1½	[illegible]	9 2
13.08	2 97	8.96	1073	12 72	107	2	10	9 0
10 53	3 10	6.26	1063	10.99	100	1½	10	9.6
11.52	2 38	7.29	1065	11 24	115	1½	10	9.4
11.07	2 19	7.30	1062	10 68	107	1¾	9	8 4
12.27	2.91	7 91	1071	12 02	131	2	8	9.2
11.11	3 15	6 99	1065	11 21	110	3	11	7 6
11.70	2.54	8.01	1063	11.58	110	3½	8	8.0
14.21	3.10	10.27	1075	14 24	130	3	13	9.3
14 25	3 17	10 49	1076	14.35	129	3	12	9 8
13 11	2.86	8 33	1075	12 99	100	3	7	7.3
12 01	2.91	7.84	1068	11.68	107	3½	8½	8.0
12.40	2 96	8.19	1070	11.94	100	1½	11	9.0
13 60	3 00	9.32	1076	13.67	104	2	10	9.7
11.46	3 03	6 89	1066	11.19	95	3½	9½	9.6
13.49	3 12	9.21	1076	13 37	97	[illegible]	12	10.3
9.97	2.43	5.63	1060	9.66	124	4½	13	8.6

Character of the Varieties of Sorghum as to Habits of Suckering.

Owing to the importance of having a uniform crop of cane without any admixture of immature stalks, for the purpose of sugar production, observations were made in the field upon the several varieties of sorghum under cultivation in 1882 for the purpose of determining their character in respect to throwing up suckers from the roots and offshoots from the parent stalk.

The following different classes appeared pretty well defined; but it often happened that one variety would have the characteristics of two or more classes:

First class.—A single stalk from the seed, without suckers from below or offshoots from the stalk.

Second class.—Two or more stalks from the seed, maturing with equal rapidity, and without suckers or offshoots.

Third class.—A single stalk from the seed, with no suckers from the roots; but with offshoots from the upper joints of the parent stalk.

Fourth class.—A single stalk from the seed, without offshoots; but with suckers springing up from the roots, and maturing much later than the original stalk.

Fifth class.—A single stalk from the seed, with no suckers from the roots; but with offshoots from every joint of the parent stalk.

It will, I think, be obvious that, other things being equal, the several varieties of sorghum will, for the purpose of sugar production, be valuable according as they belong to the above classes in their order, viz, those of the first or second class most valuable; those belonging to the third next, and so in order.

It was generally found, however, that each variety belonged to two or more of the above classes; and below is given the results of observations upon fifty-two varieties, October 14th, one hundred and forty-three days after planting, see page 121:

Class 1.—Nos. 8*b*, 10, 11, 16*c*, 17*c*.

Class 3.—Nos. 3*b*, 7, 8*a*, 12, 14, 16*a*, 16*b*, 18*a*, 21, 22, 25, 28, 29*a*, 29*b*, 33, 35, 37, 39, 40*b*.

Class 5.—Nos. 2, 3*a*, 4, 5, 6, 34.

Classes 1 *and* 2.—Nos. 9*b*, 15*a*.

Classes 2 *and* 3.—Nos. 9*a*, 9*c*, 13, 17*a*, 17*b*, 19, 23, 30.

Classes 2 *and* 4.—No. 1.

Classes 3 *and* 4.—Nos. 20, 24, 26, 27, 32, 36, 38, 40*a*.

Classes 3 *and* 5.—No. 31.

Classes 1, 3, *and* 4.—No. 18*b*.

Nos. 1 to 6, inclusive, were Chinese; Nos. 7 to 19, African; Nos. 29 and 30, Indian; and the remainder from the United States.

It will of course be understood that the above classification is only relative; and upon other soils, and in different conditions than those which prevailed with the plat upon which the above varieties were grown, these sorghums would pass from one to another of the classes.

This classification, however, will show the relative tendency of these varieties under conditions which were for each the same; and for any soil or any climate the choice would be fully justified of only such varieties as stood near the head in the above classification. Of course the relative weight of crop of each variety, its time for maturing, and its relative content of sugar, are also to be taken into consideration in selecting the variety best adapted to any given locality.

CHAPTER V.

(*a.*) Selection and preparation of ground, planting, and cultivation.
(*b.*) Selection and preparation of seed.
(*c.*) Time, from planting, to reach certain stages of development.
(*d.*) Time for harvesting crop.
(*e.*) Importance of an even crop.
(*f.*) Effect of removing seed, etc.
(*g.*) Effect of stripping cane.

SELECTION AND PREPARATION OF GROUND, PLANTING, AND CULTIVATION.

In general, the sorghum crop, in its demands upon the soil and climate, and in its method of planting and cultivation, very closely resembles Indian corn (Zea mais), with which every one is practically familiar. But this general statement demands modification. During the earlier stages in the life of the sorghum, the plant is feeble, and liable to be easily choked by weeds. Although the resemblance in its culture is so close to that of maize, and the expense generally regarded as about the same per acre, it is to be remembered that it is a crop which, for seed, forage, sugar, and syrup combined, far surpasses maize in value, and that any increase in the aggregate value of these products (which may be secured by greater care in the preparation of the soil and cultivation of the crop), will be fully justified by the economical results.

It is, of course, hardly possible to lay down directions as to each detail of cultivation applicable to every soil and locality; but, in general, such soil and such culture as would secure a good corn crop will suffice.

Like maize sorghum requires, for its best development, heat and light; but, unlike maize, it is found to successfully withstand even prolonged drought, provided only that it shall have secured a fair start: and, in fact, the maximum of sugar has been found, in every variety of sorghum under examination, to have been developed during a season of drought (that of 1881) so severe that the crops of maize, in the same section, were almost a complete failure.

This subject will be considered in another part of this volume in detail.

For the growing of sorghum, then, good corn land should be selected,

with a warm exposure; and the crop, if in drills, should be planted with them generally running east and west, so that the fullest access of sun and heat may be secured.

If practicable, the field should be chosen so as to be sheltered from heavy winds, which, by prostrating the crop, increase greatly the expense of harvesting, and injure its quality.

The character of soil and fertilization necessary, will be the subject of a special chapter.

Preparation of the Soil.

Having selected the field, the aim should be to put it in a condition of perfect tilth, more like a garden than a field, by continual cultivaation, effectually destroying weeds, and thoroughly pulverizing the soil, so that subsequent cultivation is rendered easy and rapid.

To this end it should be constantly remembered, that any additional labor at the outset, in preparing the soil for the crop, saves more than its equivalent in after cultivation, and greatly increases the value of the crop. The main points are, first, to see that the weeds shall not be allowed to get the start of the crop; and it is, therefore, to be advised strongly to run a cultivator over the ground, and drag and redrag the ground within a day of the time of planting, so that no weeds shall have even a day's start of the crop. Next to secure at the outset a good, even stand of cane, and avoid any occasion for replanting: not so much on account of the trouble and additional expense, as that, by replanting, it is impossible to have all the crop come to maturity at the same time—a matter of the utmost importance in the production of sugar.

Owing to the importance of having a field free from weeds, it would be well to have sorghum follow some hoed crop (as corn, potatoes, or tobacco); or, if such land is not available, to secure the destruction of the weeds by fall plowing and continuous working of the land until ready to put in the seed.

By deep fall plowing a deep tilth is secured, favorable to the full development of the roots of sorghum, and assists it to withstand drought; also, it will tend to destroy, through winter freezing, those weeds which may give trouble in the spring. Especially is this treatment necessary upon new land. In the spring, after having thoroughly broken up the ground by deep plowing, the drag, roller, or smoothing harrow, should be used, after the ground is warm, until the soil is suitable for a garden, free from weeds, lumps, and litter, smooth, and ready for planting.

Time for Planting.

The time for planting will, of course, depend upon the locality. The main thing desired, is that an even, uniform stand shall be secured at the first planting, free from weeds as possible.

Since the weeds and foul seeds are always ready to start so soon as the warmth is sufficient for germination, it is well to defer planting until the growth, fairly begun, shall be stopped by the cultivator and harrow, and the weeds destroyed.

By so doing the ground is made warm as well as clean. Nothing is gained, and there is great risk, in planting too early. As a rule, the planting is to be done only at the time when the ground is so warm and moist that the germination of the seeds shall proceed at once without interruption. If planted at such time, the plants will make their appearance within three or four days.

The testimony is almost universal, that the latest planting has secured the best crop, and required the least care in its production.

By late planting, the crop has a better chance with the weeds, and by proper cultivation for the first month, will quite overshadow and destroy them.

Amount of Seed for Planting.

The number of seed, of course, varies with the kind, and with the different lots of the same variety, but averages about 25,000 to the pound.

Professor Henry found 27,680 seed of the Early Amber; and I found in one specimen from Virginia, 19,000; and in another from Minnesota, 31,800 seed to the pound. Owing to the extreme importance of securing a good stand of cane at first planting, it is always best to plant two or three times as much seed as will be necessary in case it all grows. By this means, of course, in most cases, it will be necessary to thin out the plants, which involves little work, as it may be speedily effected by the hoe, so soon as the cane is about five or six inches high. In the event of failure more or less complete to secure a good stand, the choice is presented of either replanting the whole, if there remains time, or to make the best of such as may have started. In this latter case most persons will be greatly surprised to find how large the crop is at the harvest. In any event, do not plant in the vacant spaces of the field, unless the object is only the production of syrup from the crop. For sugar, this second planting would practically be worse than useless.

Two quarts of seed, if fairly distributed, would be quite enough to the acre; and if all the seed was good, there would be need even then of thinning out the crop: but, as equal distribution of so small an

amount of seed is practically impossible, it is better to plant at least three or four quarts to the acre, with the expectation of thinning out at the proper time.

Method of Planting.

Having thoroughly prepared the ground, the planting may be done in drills or in hills, as in each locality may have been found to give with corn the best results. Of course, no general rule will apply; for not only is there a difference in the soils, but also in the several varieties of sorghum. Of those who advocate planting in hills, some declare that the crop is thus better able to stand up in the wind—a most desirable result; also that, by an opportunity for cross cultivation, the weeds are more readily kept down.

The several methods of planting recommended by cultivators are given below, and for the convenience of those who may wish to know the number of stalks to the acre, and estimate the weight of crop of the several varieties of sorghum, from the table, page 74, giving the average weight of the stripped stalks, the following table has been prepared, giving, according to the several modes of planting, the

Number of Stalks per Acre.

In drills	4	feet apart, and	3	stalks to the foot	= 32,670
"	$3\frac{1}{2}$	" "	3	" " "	= 36,300
"	$3\frac{1}{2}$	" "	2	" " "	= 24,200
"	3	" "	3	" " "	= 43,560
"	3	" "	2	" " "	= 29,040
"	$3\frac{10}{12}$	" "	3	" " "	= 34,090

In hills	4	feet by	4	feet apart, and	6	stalks to the hill	= 16,400
"	$3\frac{1}{2}$	"	$3\frac{1}{2}$	" "	5	" "	= 17,730
"	$3\frac{1}{2}$	"	2	" "	4	" "	= 24,895
"	3	"	3	" "	6	" "	= 29,040
"	3	"	3	" "	4	" "	= 19,360
"	3	"	2	" "	4	" "	= 29,040
"	4	"	2	" "	4	" "	= 21,780
"	$3\frac{10}{12}$	"	$1\frac{1}{2}$	" "	6	" "	= 32,120

Upon good, strong land the cane may be planted in drills three feet apart, with stalks only four inches apart in the drill, giving 43,560 stalks to the acre.

It is thought that, by close planting, the growth of weeds is more speedily checked by being sooner overshadowed by the sorghum plants; also, that the growth of suckers is far less. On the other hand, the exclusion of light and heat retards the production of sugar in the plant; and, if the stalks are too close, their development is less, and

they are inclined to be long, spindling, and weak, with low content of sugar. It is very much to be desired that careful comparative experiments shall be made, to determine the relative effects of open and close planting, since a maximum weight of stalks per acre may be at the expense of the possible amount of sugar, or even of syrup. Recent results with maize give reason to believe, that, should the distance between the drills or hills of sorghum be very much increased over that at present given, the result would be found very satisfactory.

Marking the land may be done after the rolling, with an implement consisting of a plank resting upon three or four short runners at least 3 inches wide, so as to give a good track fixed at the proper distances; and great care should be exercised to have the rows as straight as possible, for the convenience of after cultivation.

The planting may be done by hand, or with the planter. The one horse "Keystone Planter" is reported by Professor Henry, of Wisconsin, to do perfect work, planting about an acre an hour, with the rows four feet apart, dropping the seed regularly every ten inches, and covering it half an inch, three-fourths, or an inch as may be desired, and at an expense of not over 25 cents per acre for planting. The "Mound City One Horse Corn Drill," and the "Union Planter," are also said to give entire satisfaction. The price of the above planters is about $18. In using them, it is necessary that the seed shall have been

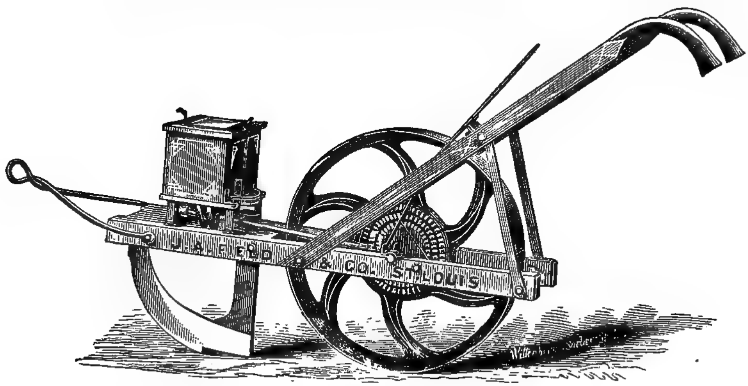


Plate XVI.

carefully cleaned and free from hulls. The depth to which the seed should be covered will depend much upon the soil and its conditions of moisture and temperature. Unless the soil is very dry, a half inch is the proper depth; and deep planting should be carefully avoided.

The light one horse planter is much to be preferred to the two horse, especially if the ground by thorough preparation has been mellowed,

since there is danger that the heavier planter may plant the seed too deep.

This planter is represented in Plate XVI.

Cultivation.

The main object after the planting of the sorghum, is to keep the weeds in subjection until the crop has so far advanced as to be able to care for itself.

It is now that the previous cultivation of hoed crops upon the field, the fall plowing, the frequent cultivation and harrowing of the land up to the day of planting, are seen to have been of great value.

After planting, these last operations are continued uninterruptedly until the plants are about two feet high. It is a common practice, a few days after planting, to drag the field over once or twice with a light harrow; and this is even done after the cane has made its appearance. But, if the seed was planted when the earth was thoroughly warm and moist, and directly after a thorough cultivation, harrowing, and rolling of the land, it will be found that the weeds will have made no appreciable start before the cane is so well up that the hills or drills are easily recognized, and then the work with the cultivator and the hoe should begin, and be continued. So soon as the plants are about six inches high, they should be thinned out, and this operation may easily be performed with the hoe. After the plants have attained a height of 12 or 18 inches, care should be taken to avoid deep cultivation, especially near the plant, in order not to disturb the rootlets of the growing plant, which extend out near the surface. In short, the care of the crop, after planting, is practically identical with that of maize, with this difference, that the young sorghum is more delicate and requires more attention than does maize. At the present, it is hardly known whether hilling or flat culture is best; but at the first it is best to leave the land level, in order that the harrow may reach the weeds. By many it is asserted that the hilling results in throwing out of suckers, a most undesirable result, although it does not as yet appear established as an effect of hilling.

It will probably be found, in each locality and season, that the course to be pursued will vary with the conditions prevailing, and that neither the one course nor the other will be found best for general application.

In certain sections of the country, the best results have been secured by what is termed ridge culture. Instead of marking, as usual,

for the planter, the land is thrown up into ridges and the seed planted upon these. This method is especially adapted to a wet, backward season. On the other hand, in Southern Kansas, where there is a lack of sufficient moisture, the opposite system, known as "listing," is said to give excellent results with both sorghum and maize. In this method, by means of the listing plow (sub-soil), furrows are laid in the field and the seed is planted in these, where is found moist earth, and where the roots, going deeper, are able to reach the necessary supply of moisture.

SELECTION AND PREPARATION OF SEED.

The first thing to be considered in the production of a crop of sorghum, is the selection of that variety which has been found, by actual and continued experience, to be suited to the particular locality where the crop is to be grown.

Since, practically, there is no difference in the demands upon the soil which one variety makes as compared with another, the main thing is to select that variety which in the given locality will mature long enough before frost occurs to enable the crop to be worked up.

By consulting the tables on pages 121 and 122, it will be seen that the period from planting to maturity varies with the different varieties from 90 to 170 days, and that between these limits all those cultivated will mature their seed.

The farmer generally has a choice of several varieties, all sufficiently early for his climate and locality; and, in such case, it is desirable to make actual test of several, in order to learn which he had best adopt.

Owing to exposure, the crop may be liable to be prostrated by heavy winds, in which case those varieties best able to withstand such storms are much to be preferred. A short, heavy stalk, with a relatively small panicle, is then to be chosen, and reference to the table upon page 74 will be a guide in such selection.

More frequently it may happen that, owing to the length of season in certain localities, several varieties may be planted, which, by reaching maturity in succession, will enable the farmer not only to secure his crop of seed from each, but to prolong his season for working up the crop for sugar, having each crop ready for the mill when it has reached its best condition. For example, one might select the following varieties: Early Amber, Link's Hybrid, Early Orange, Liberian, and Honduras, the number of days required from planting to maturity being, respectively, 90, 105, 116, 130, and 140; or, for the Early Amber, the White Liberian, and for the Early Orange, the White

Mammoth could be substituted. All the above are among the best of our varieties.

Other things being equal, it is desirable that those varieties be selected which shall give the heaviest crop, since, if worked at their best, the amount of sugar or syrup produced is proportioned to the weight of the cane; and, by reference to the tables on pages 74 and 75, it will be seen that, generally, the weight of the crop is nearly proportioned to the time necessary for it to mature. For example, we find the average weight of the stalks, of the above varieties, as cut in the field, and after stripping, to be as follows:

	Average weight of stalks as cut.	Average weight of stripped stalks.
Early Amber............	1.39 pounds.	.96 pounds.
Link's Hybrid	1.90 "	1.38 "
Early Orange....	2.12 "	1.47 "
Liberian.	2.26 "	1.81 "
Honduras.....	2.54 "	2.14 "

A field, then, which would produce a crop of ten tons of Early Amber stripped stalks, would produce over twenty tons of Honduras stripped stalks. But the advantage of a prolonged season for working up the crop would prove so great that the difference in yield of crop would be more than compensated.

The Choice of Seed.

Having selected the proper variety for cultivation, the selection and testing of the seed is of first importance.

It is by many urged that, for cultivation in any northern locality, seed should be obtained further south; not that earlier maturity is thus secured, but a heavier crop. It being asserted, as the result of experience, that, after two years' planting, there was a marked falling off in the weight of the crop. The general opinion prevailing among those who hold to this view, is seen in the following from the proceedings of the Minnesota Cane Grower's Association:

The weight of opinion was decidedly in favor of seed brought from the latitude of St. Louis. Some cane growers had sent their seed to Missouri and Kansas, to have a crop grown and its seed returned. Among the decisive facts reported, Mr. Miller stated that his seed, imported from Southern Indiana 11 years before, had produced, on its first sowing, stalks from 12 to 15 feet high; but, by planting the seeds of each crop, its successors showed a declining height of cane, until it grew but 7 or 8 feet high. Mr. Wylie had averaged, with seed brought from the South, 273 gallons per acre; the following year, using his own seed, he obtained but 223 gallons, a falling off of 50 gallons. The president of the convention had found, as a general thing, that the deterioration of seed was

not very marked till the third year. The southern seed did not excel so much in an earlier ripening of the crop as in its increased product, the excess, in some cases, amounting to one-third. The sentiment of the convention was expressed in the following resolution:

Resolved, That Early Amber cane seed, grown in the latitude of St. Louis, is the best seed for Minnesota for two years.

If every statement in the above be accepted without question, the conclusion expressed in the "resolution" appears by no means established, since we might expect a falling off in crop, as with Mr. Miller, if the sorghum was continuously grown upon the same land, and especially as nothing is said about any means for keeping up the fertility of the soil.

In the case observed by Mr. Wylie, a difference of less than 20 per cent in the product, and that but for a single year, is a result which, in one place or another, is experienced every season with all our crops; and often, as in 1881, over nearly the whole country, and with almost every crop grown. Such differences are readily explained upon other grounds.

In a matter of so great moment as this—the proper selection of seed—it is most unfortunate that such questions are settled by "resolution," rather than by careful experiments. Hasty generalizations are the bane of science; and the history of this sorghum industry during the past thirty years, well illustrates the fact, that the extent of our knowledge is not always measured by the amount of our experience.

In connection with this matter, the following results with seed of apparently the same varieties, grown in all parts of the country, planted the same day and upon the same plat of ground, are of interest.

Variety Honduras (planted May 6th, 1880, at Washington, D. C.).

Source of seed.	Local name.	May 11th.	May 14th.	Days to maturity.	Average weight stripped stalks.
South Carolina......	Mastodon	Few up.	All up.	128	1.99 pounds.
Louisiana..........	Honey Cane...	"	"	133	2.24 "
Maryland..........	Honduras	"	"	148	1.24 "
Alabama............	Sprangle Top.	All up.	"	153	1.87 "
Tennessee	Honduras.....	More up.	"	157	2.11 "
Missouri	Honey Top....	Few up.	"	163	2.14 "
Texas..............	Honduras.....	"	"	164	2.16 "

Variety Liberian.

Source of seed.	Local name.	May 11th.	May 14th.	Days to maturity.	Average weight stripped stalks.
Tennessee.	Oomseeana	Few up.	All up.	127	1.77 pounds.
Ohio	Liberian	"	"	131	1.88 "
"	"	"	"	134	1.85 "
Virginia	Chinese	"	"	137	1.36 "
Alabama	Sumac	"	"	152	1.64 "
South Carolina	Imphee	All up.	"	155	1.58 "
Alabama	Sumac	Few up.	"	168	1.54 "

Variety Early Amber.

Source of seed.	Local name.	May 11th.	May 14th.	Days to maturity.	Average weight stripped stalks.
Virginia	Early Amber	All up.	All up.	77	1.06 poonds.
Missouri	" "	"	"	80	1.02 "
Minnesota	" Golden	"	"	80	1.02 "
Ohio	Golden Syrup	Few up.	"	87	1.02 "
Kansas	Early Amber	All up.	"	89	.99 "

From the above it would appear, that there was no difference noticeably due to the locality whence the seed was obtained, either in the rapidity of germination, in the weight of the crop produced, or in the time required for maturity.

In this last particular, there is a great difference, as, for example, in those varieties classed as Liberian and Honduras: but it will be observed, the specimen of Liberian requiring most time to reach maturity came from Alabama; the specimen of Honduras which required the longest time to mature came from Texas; and the specimen from Missouri was practically identical, not only in this respect, but in weight of crop.

The Testing of Seed.

Owing to the fact that, through lack of care in the harvesting and curing of the seed, its vitality may be destroyed, it is a precaution which should never be omitted by the farmer, that he should, shortly before the time for planting, make a careful test of his seed, in order to determine its vitality; otherwise, he may find, when it is too late, that his fields require replanting, the season being too short to permit this with any assurance of a mature crop of cane.

In order to test the seed, it is only necessary to take a shallow box, with a cover (an empty blacking-box will do, but it should be carefully washed clean); the box should be half filled with clean sand—not earth nor gravel, but sand—and this sand should be saturated with

water; then allowing the excess of water to escape by inclining the box. Into the box, an average sample of 100 seed should be dropped upon the moist sand; and, being covered, it may stand in a moderately warm room, at about 70° F. Every day, the cover should be removed, and after from three to five days, those seed which retain their vitality will have germinated, and may be counted. By this means, one may easily learn the per cent of vitality of his seed, and it will be found that fairly good seed will give at least 90 out of 100.

Of course, if the percentage is less, a proportionally larger amount of seed must be used in planting. Owing to the importance of securing at the start a uniform stand of cane, and to avoid the danger of re-planting, as well as expense, it would be well, in every case, to duplicate the test of the seed, to be assured against failure from poor seed.

The Preparation of Seed for Planting.

According to the testimony of many, the plants will come forward more rapidly if the seed is soaked in lukewarm water for twenty-four hours before planting—and, indeed, it has been advised by some to sprout the seed before planting; but even the advocates of either soaking or sprouting seed admit that there is risk of losing the seed, if the ground should, at planting, prove too cold or too dry.

By reference to the tables just given, it will be seen that, of all the varieties planted, and of the seed received from so many sources, there was not one which was not fully up within a week after planting; and the same was true of all the forty-eight varieties planted at that time.

If properly planted, and with the ground in good condition, it is questionable whether there is any gain in soaking or sprouting the seed, while there is far more danger of losing it if the weather is unfavorable.

It may happen that the seed is liable to be destroyed by wire-worms, as was the case in one of the fields of the Department of Agriculture, at Washington; and, in this case, a stand was only at last secured by rolling the seed, first in coal tar, and afterward in plaster (gypsum) powder. Whether this remedy was efficacious can hardly be affirmed, since it may have been, that, by the time of this planting, the worms were either dead or had secured other subsistence.

It would appear best to plant the seed in its ordinary condition, and, in case the ground is very dry, but warm, to plant a little deeper than usual, and to take care to press the earth firmly about the seed, with roller, hoe, or foot.

TIME FROM PLANTING REQUIRED BY THE SEVERAL VARIETIES OF SORGHUM TO REACH CERTAIN STAGES OF DEVELOPMENT.

The following table will give the number of days required by 31 American varieties, and 3 received from France, to reach certain stages of development. This table can be only regarded as relatively true for the several varieties as the season of 1881 was in Washington (where these were grown), one of almost unprecedented drought, as will be seen by reference to tables giving the meteorological data for the several years of experiment, the results of which are largely recorded in this volume.

For the purpose of accurately recording the observations in the field from day to day, the following list of stages was made out:

Stage.	Development of Plant.
1	About one week before opening of panicle.
2	Immediately before opening of panicle.
3	Panicle just appearing.
4	Panicle two-thirds out.
5	Panicle entirely out; no stem above upper leaf.
6	Panicle beginning to bloom on top,
7	Flowers all out; stamens beginning to drop.
8	Seed well set.
9	Seed entering the milky state.
10	Seed becoming doughy.
11	Seed doughy, becoming dry.
12	Seed almost dry, easily crushed.
13	Seed dry, easily split.
14	Sucker in bloom.
15	Sucker seed in milk.
16	Sucker seed in dough.
17	Sucker seed hard.
18	After sucker seed hard.

By the sucker in this case, is meant the off-shoot from the upper joints of the parent stalk upon which, if the season permits, panicles will mature. It will be seen, by consulting the table, that the Honduras variety was a month later than the Early Amber in showing its panicle, and that before the Honduras was in bloom the Early Amber was quite ripe.

DEVELOPMENT OF SORGHUM — DAYS AFTER PLANTING—SEASON OF 1881, AT WASHINGTON, D. C.

	Panicle just appearing.	Panacle entirely out.	In full bloom.	Seed in milk.	Seed in dough.	Seed hard.	Height.			
							54 days after planting.	69 days after planting.	88 days after planting.	108 days after planting.
							Feet. In.	*Feet. In.*	*Feet. In.*	*Feet. In.*
Early Amber	72	77	82	90	97	105	2.9	5.3	8.0	9.0
Early Golden	70	76	82	90	97	105	3.4	5 9	8 8	8 9
White Liberian	70	76	82	90	97	105	3.2	6.3	8 6	8.6
Black Top	72	77	80	82	92	105	3 0	5.10	6.0	6.6
African	72	75	81	87	97	108	2.8	5.2	6.0	8.0
White Mammoth	77	85	105	118	131	139	2 0	4.6	8 0	9.9
Oomseeana	72	76	82	87	97	109	2.6	5 8	8 0	8 0
Regular Sorgho	72	77	82	87	97	109	2.9	6.2	9 6	9.6
Link's Hybrid	87	92	97	103	109	118	2.3	5.6	9.6	11 2
Sugar Cane	82	87	92	102	107	112	2.3	5 6	9.6	11 0
Goose Neck	75	79	82	90	102	112	2.6	5 10	9.0	9.6
Bear Tail	72	75	77	82	102	109	2.9	6.4	8.6	9 0
Iowa Red Top	72	77	85	92	102	109	2 8	5 10	8.0	9.0
New Var., Stump's	72	75	79	82	92	105	2.6	5 8	9.0	9.6
Early Orange	82	90	97	105	112	122	2.0	4.6	8 3	9 3
Orange Cane	80	85	92	102	112	118	2.4	4.8	8.4	9.0
Neeazana	77	82	87	92	105	....	2.8	5.2	7.6	7.9
Wolf Tail	92	102	105	..	...	....	2.3	5.2	8 6	11.0
Gray Top	97	102	107	.	...	...	1.9	4.2	7 3	9.0
Liberian	92	102	108	112	..	...	1.9	4.4	7.6	9.6
Mastodon	92	102	109	....	..	....	2.4	4.8	8 6	11.0
Honduras	102	109	...	..	.	...	1.10	4.0	7.6	11.0
Sugar-cane	72	76	80	87	97	105	2 6	4.10	7.0	7.6
Hybrid, Wallis	72	77	82	90	102	112	2.6	5.10	9 0	9.0
White Imphee	82	90	97	109		....	1.8	4.0	7.10	8.6
Goose Neck	82	87	92	102	112		1.6	4.2	8 6	9.0
White African	75	79	82	90	97	105	2.3	5.0	8.0	8 6
West India	95	102	107	112	..	....	1.8	4.4	7.0	8.6
Sugar Cane	72	77	85	92	..	....	2.6	5.4	7.0	7.6
Hybrid Lib. & Oom	72	77	82	92	.	...	2.0	4 8	6.3	6 6
Holcus Saccharatus	82	92	102	112	....	...	2.3	5.4	8.6	10.0
Holcus Sorghum	80	85	92	..	......	...	3 0	5 6	10 6	11.0
Holcus Cernus	87	93	99	112	...	....	2.8	5 0	9.3	9 6
Honey Cane	102	107	112		..	...	2 0	4.8	8.6	12.0

The following table is similar to the last, and gives the time required to reach certain stages of development by several new varieties received from China, Africa, and India, for purpose of comparison with several American varieties. These results were secured in Washington, in 1882, and these results are to be compared fairly with only those obtained the same season, since, as will be seen upon page 147, the climatic conditions of 1881 varied greatly from those prevailing in 1882. This matter will be again discussed.

TIME, FROM PLANTING, TO REACH CERTAIN STAGES OF DEVELOPMENT.

The following table gives the number of days, after planting, required by the several varieties to reach certain stages of development.

This table can be regarded as only relatively true, for these varieties, during the season of 1882, which season was remarkable for an unusual rain-fall during the summer months, thus retarding the development of the plants, probably, beyond the period they would require under ordinary conditions of climate.

A reference to the meteorological data of this year, as compared with 1881, will make the difference in the two years manifest:

TIME, FROM PLANTING, TO REACH CERTAIN STAGES OF DEVELOPMENT.

Row number.	VARIETY.	Maximum height attained.	Days from planting to maximum height.	Days from planting to blossom.	Days from planting to seed in milk.	Days from planting to seed in dough.	Days from planting to seed hard.
1*a*	Yellow Cap Glutinous	9 3	74	67	....	....	....
1*b*	" " "	....	....	....	....	....	....
2	Separated Head Stalks Red.	9 3	74	53	60	74	81
3*a*	Separated Head Stalks White	9.6	74	67	77	88	97
3*b*	" " " "	9.6	....	....	....	....	97
4	Second Autumn Red	9 4	67	60	74	81	90
5	Horse Tail Glutinous	10 0	86	72	79	90	104
6	Large People's Red	9 6	74	74	88	95	117
7	Undendebule	9 6	93	90	107	115	124
8*a*	Ukubane	9 6	93	79	86	93	100
8*b*	"	5 6	93	86	100	107	116
9*a*	Jyangentombi	8 6	86	93	107	110	116
9*b*	"	7 0	93	86	100	114	136
9*c*	"	9 0	....	....	....	....	....
10	Iyenga	....	....	....	....	....	....
11	Ibohla	11 4	100	97	107	111	115
12	Dindemuka	8.0	100	86	93	124	136
13	Uboyana	8.2	109	100	....	124	143
14	Umgatubanda	7.0	100	86	100	107	115
15*a*	Ubelana	9.0	93	93	107	115	124
15*b*	"	8.3	....	....	143	....	....
16*a*	Ufatane	8 10	100	93	107	115	124
16*b*	"	6.1	100	93	108	124	143
16*c*	"	7.8	100	93	108	124	143
17*a*	Unkunjana	9 2	100	93	107	124	143
17*b*	"	10 6	100	....	115	124	136
17*c*	"	7 5	100	....	115	124	143
18*a*	Hlogonde	8.9	109	93	107	124	129
18*b*	"	7.4	109	....	108	124	129
19	Unhlokonde	9.2	79	72	93	107	115
20	White Imphee	8.1	79	79	93	100	107
21	White African	9.6	93	86	100	107	115
22	White Mammoth	10.3	93	86	100	107	115
23	West India	8.8	100	100	105	110	115
24	New Variety, Stump	9.2	86	65	86	93	100
25	Early Amber	9.0	86	....	93	100	107
26	New Variety, H. S. Coll	9 6	86	65	79	90	100
27	Bear Tail	9.4	102	79	100	107	115
28	Iowa Red Top	8.4	86	79	93	100	107
29*a*	Black Sorgho	7.6	81	74	88	99	110
29*b*	" "	8.0	81	....	....	99	110
30	Red Sorgho	9.2	95	88	102	110	131
31	Link's Hybrid	9.3	93	93	107	115	130
32	Standard Harrall	9.8	110	93	107	124	129
33	Neeazana	7.3	86	75	86	93	100
34	Gray Top	8.0	93	79	93	100	107

Time, from Planting, to Reach, etc.—Continued.

Row number.	VARIETY.	Maximum height attained.	Days from planting to maximum height.	Days from planting to blossom.	Days from planting to seed in milk.	Days from planting to seed in dough.	Days from planting to seed hard.
35	White Liberian..	9 0	93	65	79	90	98
36	" "	8 8	86	72	86	93	100
37	New Variety, Link	9 7	81	81	88	95	104
38	New Variety, Haswell	9 6	74	67	81	88	95
39	Chinese Imphee,.,	10.3	74	67	81	88	97
40*a*	New Variety, Bradford..	8.6	74	74	88	104	124
40*b*	" " "	7.	74	....	.....	104	124

TIME FOR HARVESTING CROP.

When the Maximum Content of Sugar is Present in the Sorghum.

No conclusion established by the work of the Department of Agriculture, practically considered, is of greater importance than the positive ascertainment of that period, in the development of the several varieties of sorghum, when their juices contain the maximum of cane sugar.

Conflicting Testimony Before this Investigation.

On this point, there has existed, during the past twenty years or more, the greatest discrepancy in statement; and the general opinion prevailing has been very wide of the truth, as established by all these experiments.

As evidence of the great diversity of opinion concerning this important matter, which existed previous to the experiments at Washington, the following quotations are made from the reports of various experimenters:

a. In his report on "Early Amber Cane," by Dr. C. A. Goessmann, of Amherst, Mass., 1879, he says, page 9:

The safest way to secure the full benefit of the Early Amber Cane crop, for syrup and sugar manufacture, is to begin cutting the canes when the seed is full grown, *yet still soft.*

b. In the "Sorgho Hand-Book," published by the Blymyer Manufacturing Company, Cincinnati, Ohio, 1880, it is directed, upon page 8:

The cane should be cut when the seed is *in the dough*, and *several days*

before grinding, as it will be more free from impurities, if cured for a few days before going to the mill.

c. In a pamphlet entitled "Sugar Making from Sorghum," published by the Clough Refining Company, page 5, directions are given to

Harvest as soon as the *seeds begin to form*, and *before they get hard. Grind the cane, if possible, soon after it is cut.*

d. In a pamphlet entitled "The Sorgho Manufacturers' Manual," by Jacobs Brothers, Columbus, Ohio, 1866, page 4, it is stated, that—

The cane is in the best state for harvesting when part of the seed is beginning to turn black; or, in other words, *when the seed is in a doughy state.* The cane should be cut and shocked in the field, with tops on; and in this condition it may remain several months before being worked up, for the cane matures and forms more saccharine matter.

e. In a "Report on the Manufacture of Sugar, Syrup, and Glucose from Sorghum," by Professors Weber and Scovell, of the Illinois Industrial University, 1881, page 22, they say:

The proper time to begin cutting the cane, for making sugar, is *when the seed is in the hardening dough.* The cane should be worked up as soon as possible after cutting.

f. J. Stanton Gould, in a "Report on Sorghum Culture," made to the New York State Agricultural Society in 1863, page 752, says:

The seed of the cane (sorghum) continues in the dough for about a week. It is the general impression the cane should be cut during this period, as it is then *supposed* to have the greatest amount of saccharine matter; at least, this is *thought* to be true of all the varieties except the White Imphee, which is usually cut *just as it is going out of the milk or just entering the dough.*

g. In conclusion, we quote from Mr. Gould's paper, as illustrating the chaotic state in which our knowledge was prior to the work at the Department of Agriculture. Upon page 740, he says:

These conflicting opinions might easily be reconciled by a few well-directed experiments.

Again, he says, same page:

After the most careful inquiry, orally and by letter, I am unable to find that any such experiments have ever been made.

Again, he says, page 747:

These experiments are not conclusive, and the whole question needs a careful and accurate investigation.

As the result of such an investigation, we call attention to the average results of the past years, as shown in the tables given in this volume, from which it will be seen that, during each of the past three

years, it has been demonstrated beyond any reasonable doubt, that the value of the sorghum for the production of sugar increased, upon an average of the 35 or 37 varieties tested, fully 500 per cent, and in many cases 1,000 per cent, after the period when, according to the authorities cited, it was recommended that the crop should be cut up.

It will be observed, also, how completely at variance the above quoted authorities are in reference to the subsequent treatment of the crop after cutting it up, the one recommending that it be stored, even for months; the other, that it be immediately worked up. The importance of this latter course of treatment can hardly be overestimated, as appears from data herewith presented.

I remember, in 1881, that an Ohio farmer, who met me one day as I was looking over my sorghum plat in Washington, and who did not know that I had any interest in it, told me that the crop ought to have been worked up long before, for it was suffering. He also told me that he had grown sorghum for 20 years in Ohio. Now this was during the latter part of July, when, according to his twenty years' experience, he was sure that the crop was deteriorating.

Well, that plat contained some 35 varieties, and it had been daily examined for at least two months before this, and it was examined daily for at least three months after the time when this farmer, with his 20 years' experience, was convinced that it was suffering.

The results of all these examinations are published, and are accessible to you all. If you examine them, you will find that after the time when this farmer would have it cut up, and worked it, this crop increased in the amount of available sugar at least 200 per cent.

Length of Period for Working Sorghums.

Reference has already been made to the very great difference existing between the different varieties of sorghum, as to the length of time needed for them to reach maturity. It is not known that experiments have been made to determine this difference accurately, until those lately made at the Department of Agriculture. It has also been shown, as already remarked, that those varieties requiring long periods for their complete maturity, have been the varieties largely cultivated in the Northern States during the past thirty years.

The results given in the Annual Report of the Department of Agriculture, page 130, Table 96, show not only the number of days from time of planting, to complete maturity of each variety, but also the number of days during which the several varieties were in a condition for working in this latitude.

By this table, the farmer in any section of the country, may be able to select such varieties as the nature of his climate will give him reason to believe may be successfully grown; or, if his season permits, he may select several varieties, which, coming to maturity in succession, will

enable him to extend his working season, and yet have his cane of each sort in the best condition for sugar or syrup production. Planted, as these several varieties were, side by side in the same soil, and on the same day, the comparative results given in the table referred to are fully trustworthy, and could have been secured in no other way.

These results are of direct practical value to the sorghum grower, and were confirmed by the experience of 1881 and 1882.

Period for Working the Sorghums.

In the following table is given the working period for the different varieties of sorghum, the number of analyses made during this period, and the maximum, minimum, and average per cent of available sugar during this period.

The average number of analyses of each variety is 15, so that these results may be relied upon with confidence. The entire period is from July 30th to November 17th, thus allowing 110 days in the latitude of Washington for working up the crops, which may be so planted or selected among the different varieties as to enable each crop to reach its maximum value at the time of being worked up.

The average minimum of available sugar of the thirty-five varieties, is 6.44 per cent, while the average maximum is 12.51 per cent. The average of the best half of the thirty-five varieties, during the entire period, is 10.97 per cent, while the average of the poorer half during the entire working period, is 8.63 per cent. The average of the entire number during their entire working period, is 9.77 per cent of available sugar.

It will be remembered that these varieties were planted April 29th, so that the length of time for each to reach the condition represented by these averages may be readily determined, and are given in one of the columns.

As will be seen, this period varies from 92 to 139 days, and several of these later maturing varieties appear even in this latitude to have failed in reaching their best condition, as will be seen in the fact that their maximum of available sugar falls far below that of other varieties of shorter periods of development. In fact, many of these varieties can not be successfully grown for sugar, perhaps, except in the Gulf States.

Owing to the fact that the amount of syrup which may be produced from a juice depends upon the sum of the sucrose and glucose, it is obvious that syrup may be produced from the canes in any condition of maturity; but even for syrup production, it will be seen by reference to the tables of analyses of the several varieties, that the maximum of syrup may be produced at the same period when the sorghum may be

most profitably worked for sugar, since at that time the sum of the two sugars is also at its maximum. For the production, then, of either sugar or syrup, it is desirable that only such varieties should be grown in any locality as may be able to reach full maturity.

PERIOD FOR WORKING THE DIFFERENT VARIETIES OF SORGHUM.

Variety.	Number of determinations.	Number of days.	From	To	Minimum available sugar.	Maximum available sugar.	Average available sugar.	April 29th to the working period.
					Pr. ct.	*Pr. ct.*	*Pr. ct.*	*Days.*
Early Amber	24	106	Aug. 3	Nov. 17	6.06	14.62	10.12	96
Early Golden	26	110	July 30	Nov. 17	7.06	14 00	10.02	92
White Liberian	25	110	July 30	Nov. 17	6.71	14.77	10 41	92
" "	25	110	July 30	Nov. 17	6.71	15.12	10 61	92
Black Top	15	76	Aug. 15	Oct. 30	7.70	15.15	11 08	108
African	20	85	Aug. 24	Nov. 17	5.16	14.00	9 82	117
White Mammoth	9	42	Aug. 29	Oct. 10	8.46	12 51	10.60	122
Qomseeana	15	75	Aug. 16	Oct. 30	4.37	13.46	10 76	109
Regular Sorgho	7	18	Aug. 25	Sept. 12	8.90	11 76	9 78	118
Link's Hybrid	21	106	Aug. 3	Nov. 17	7 39	14 53	11.02	96
" "	23	97	Aug. 12	Nov. 17	7.98	14 87	11 36	105
Sugar Cane	23	103	Aug. 6	Nov. 17	8.17	12.81	10.86	99
Goose Neck	6	16	Aug. 29	Sept. 14	10.09	11.90	11 34	122
Bear Tail	10	56	Aug. 16	Oct. 10	7.43	11.59	9.76	109
Iowa Red Top	13	70	Aug. 11	Oct. 20	9 26	14.17	12 64	104
New Variety	19	92	July 30	Oct. 30	5.63	14.56	11.63	92
Early Orange	14	72	Aug. 19	Oct. 30	5.26	15 05	10.73	112
" "	19	86	Aug. 23	Nov. 17	6.83	12.35	9.91	116
Orange Cane	14	71	Aug. 20	Oct. 30	4 95	11 44	9 56	113
Neeazana	20	89	Aug. 20	Nov. 17	2.52	9 07	6.78	113
Wolf Tail	24	94	Aug. 15	Nov. 17	7.15	12 21	9 67	108
Gray Top	21	90	Aug. 19	Nov. 17	3 32	9.90	6 79	112
Liberian	7	38	Sept. 2	Oct. 10	4.64	11.89	8 55	126
Mastodon	9	41	Aug. 30	Oct. 10	3.64	11 87	8.66	123
Honduras	7	25	Sept. 2	Sept. 27	1.80	8 39	6.56	126
Sugar-Cane	11	62	Aug. 19	Oct. 20	2 96	10.31	7 82	112
Hybrid No. 4	4	8	Aug. 26	Sept. 3	8 85	10.20	9.45	119
White Imphee	8	56	Aug. 15	Oct. 10	8.08	15.36	11 90	108
Goose Neck	13	72	Aug. 19	Oct. 30	6 78	12.17	9 29	112
White African	20	97	Aug. 10	Nov. 15	4 93	12 04	8 21	103
West India Sugar Cane	8	49	Aug. 14	Oct. 2	7 67	14.10	10 70	107
Sugar Cane	4	23	Sept. 7	Sept. 30	6.51	11.27	8.76	131
New Variety of Liberian and Oomseeana	10	51	Aug. 8	Sept. 28	6 81	9 84	8 30	101
Minnesota Early Amber	10	53	Aug. 8	Sept. 30	8.23	12.17	10 78	101
Honey Cane	2	15	Sept. 15	Sept. 30	7 22	8 15	7 68	139

IMPORTANCE OF PROMPTLY WORKING THE CROP AFTER CUTTING.

To this point, also, reference has been made already. Its importance can hardly be overstated. If departure from this rule is *at any time* admissible, it is at least safe to say, that the conditions which would warrant such departure are as yet not determined. Prompt working of the cane so soon as cut is always safe, and any delay is fraught with unavoidable risk of loss.

This conclusion is established, as well by the work of others as by that of the Department of Agriculture.

The following results are reported by Professors Scovell and Weber, of Illinois Industrial University:

Change of sugar after cutting the cane.—On October 23rd, 1880, an analysis was made of the juice of the Orange cane, which had been cut, stripped, and topped October 2nd, and placed under shelter until examined. Juice whitish.

Specific gravity		1.091
Grape sugar	per cent.	14 66
Cane sugar	per cent.	3.55

A sample of cane, cut August 25th, 1880, without being stripped and topped, was preserved in a warm room, where it had become dry long before it was examined. On April 3rd, 1881, it was analyzed, and showed 12 per cent of grape sugar, and no trace of cane sugar.

Professor Swenson and Henry, of Wisconsin State University, give the following report of experiments in this matter. It is to be regretted that the percentage of juice expressed in each experiment was not given, in order that the real loss of sugar could have been determined, as it was doubtless much greater than the several analyses of the juice would indicate:

Effect of leaving Cane cut in the Field.

A number of stalks still in good condition, the juice of which contained 9.50 cane sugar and 3.25 glucose, were cut and left in the field ten days, during almost constant rain. At the end of the ten days the juice contained 5.98 cane sugar and 6.15 glucose. Some Early Orange cane was also cut September 20th, when the juice contained 10 50 cane sugar and 4.95 glucose, and was left in the field till November 2nd, when the juice contained 13.80 glucose, while not a trace of cane sugar was present. These experiments show conclusively, that if cane is cut or injured and left exposed to rain, the destruction of cane sugar goes on very rapidly, being in time entirely changed into glucose. The rapidity of the change depends, of course, in great degree, on the weather.

Effect of leaving Cane cut under Shelter.

In order to ascertain the effect of leaving cane under cover, two tons of Early Amber cane were cut, the juice containing 10.02 per cent of cane sugar and 3.23 per cent of glucose. One-half was topped and stripped, and both lots were placed on the floor of the barn. The change taking place may be seen from the following table:

	Cane sugar.	Glucose.
SEPTEMBER 20TH.		
The cane freshly cut	10.02	3.23
OCTOBER 4TH.		
After two weeks:		
(Stripped)	8.25	6.21
(Unstripped)	8.17	6.00
OCTOBER 19TH,		
After four weeks:		
(Stripped).	7.41	3.41
(Unstripped)	7.64	3.74

	Cane sugar	Glucose.
NOVEMBER 2ND.		
After 6 weeks: (Stripped)	8.26	3.74
DECEMBER 20TH.		
After 13 weeks: (Stripped)	8.45	6.80

To judge by the table, the cane changes very slowly, but in reality the loss of sugar is quite rapid. If no loss of sugar took place, the juice would of course become richer in sugar, on account of the evaporation of part of the water. In reality this is not the case. The cane sugar becomes gradually changed to glucose, which in turn is destroyed by fermentation. In this way the juice may become even richer in sugar, but the quantity of juice is greatly diminished. The juice becomes also very acid. The effect produced by shocking the cane in the field was tried, with very unsatisfactory results, the cane sugar being destroyed very rapidly.

In the following table is given the comparative results obtained in the manufacture of syrups from several varieties of sorghum. In the one case, the crop had been suckered, and the stalks were cut and promptly worked; in the second case, the crop had not been suckered, but was promptly worked after cutting; and, in the third case, the crop had been unsuckered, and was allowed to remain from one to four days after having been cut, topped, and stripped, before it was brought to the mill for pressing. In each case the juices expressed and the syrups made from them were analyzed with the following results. The amount of any single lot of stalks was generally too small to permit a lot of syrup to be made from it, but each lot of juice and of syrup was so near alike in quantity, that the average fairly shows the effect of suckers, and of lack of promptness in working. It will be seen, that, of the sixteen varieties of sorghum experimented upon, the presence of suckers had, in five cases, lowered the available sugar to a minus quantity, while the average of the sixteen juices showed a loss of over 48 per cent of the available sugar, and of nearly 42 per cent in the syrups made from their juices: also, that, in none of the eleven syrups, and in but one of the sixteen juices from the stalks which had been kept for a few days before working, was the available sugar other than a minus quantity.

EFFECT ON SORGHUM OF LETTING IT LIE AFTER CUTTING UP.

Per Cent of Available Sugar.

	Suckered and promptly worked.		Unsuckered and promptly worked.		Unsuckered and worked after one to four days.	
	Juice.	*Syrup.*	*Juice.*	*Syrup.*	*Juice.*	*Syrup.*
	10.87	35.90	12.05	28.16	— 9.90	—45.50
	10.63	35.18	12.76	23.90	—10.10	—35.72
	11.20	37.40	9.61	16.19	—13.43	—68.60
	8.10	20.20	.09	21.56	— 1.49	—28.40
	7.81	.....	2.22	6.26	— .65	—45.78
	8.18	. ...	1.84	35.12	— 7.27	—12 20
	5.45	.....	—1.05	18.30	— 9.68	— 2.50
	7.26	.....	— .01	6.36	— 1 67	—11.34
	7.10	.....	3.16	4.30	— 2.98	— 5 68
	9 91	.....	5.97	25.06	— 2 24	— .04
	9.52	.....	8.02	20.34	— 3.84	— 3.82
	4.30	.....	— .65	.....	— .65	.....
	.23	.....	— .99	. ...	— .99	.....
	.50	.....	— .33	...	—10.30	.....
	6.95	.....	3.42	.....	— 1.85	.....
	1.97	.....	.78	.....	— 9.12	.. ..
Average,	6.87	32.17	3.55	18 71	— 5.15	—23.60

Experience of Dr. C. A. Goessmann with Sorghum cut some time before Working.

Dr. Goessmann, of the Massachusetts Agricultural College, in his report of experiments upon the Early Amber Sorghum, gives a similar series of results of analyses of juices entirely comparable with those just given. (*Vide*, report on "Early Amber Cane, by Professor C A. Goessmann, 1879.") His results are so valuable, as fully confirming our own, and establishing the fact, that, what has been found true during the past four years in this latitude, is equally true in Massachusetts—viz: that certain of the varieties of sorghum may, even in that high latitude, attain a content of sugar fully equal to that of the sugar cane of the tropics, that his analytical results of examination are here appended. Of these, there were but eighteen complete results; and, for purpose of comparison, the results here attained of the average of juices having the same specific gravity as those analyzed by Dr. Goessmann, are given in the table alongside. It will be observed that the results attained by him, from August 15th to September 18th, inclusive, are almost identical with my own, showing, from the first, a gradual increase in the sugar:

COMPARISON OF RESULTS OBTAINED BY DR. GOESSMANN, AT AMHERST, MASSACHUSETTS, WITH THOSE OBTAINED AT THE DEPARTMENT OF AGRICULTURE.

1878.	Goessmann.				Collier.				No. of analyses.
	Sucrose.	Glucose.	Specific gravity.	Total Sugar.	Total Sugar.	Sucrose.	Glucose.	Specific gravity.	
Aug. 15	0.00	2.48	1.017	2 48	......	......	......	......	......
16	0.00	4.06	1.023	4 06	4 42	1.15	.327	1.023	3
20	2.15	3.47	1.032	5 62	6.11	2.16	3.95	1 032	17
24	3 00	3.70	1.035	6 70	7.40	3.29	4.41	1.035	23
27	4.13	3.65	1.040	7.78	8 35	4.41	3 94	1 040	18
30	3.81	4.00	1.038	7.81	7 86	3.43	4.43	1 038	21
Sept. 2	4 41	3.85	1.043	8 26	9 21	4.95	4.26	1.043	22
9	6.86	3.21	1.048	10 07	10 07	6 08	3.99	1.048	36
9	6.81	3.77	1.052	10.58	10 82	7.64	3 18	1.052	43
18	7.65	3.57	1 054	11 22	10.86	7.74	3 12	1.054	49
18	8.49	3.16	1 056	11.65	11 57	8.61	2 96	1.056	52
18	5.85	3.16	1 046	9.01	9 48	5.72	3 76	1.046	30
18	.60	10.00	1 052	10.60	10 82	7.64	3.18	1.052	43
21	......	......	1.053	......	11 00	7.58	3 42	1 053	43
23	......	......	1.061	......	12 61	9.88	2.73	1.061	76
29	8 16	3 61	1.060	11 77	12.45	9 80	2 65	1.060	100
Sept. 25	6 27	11.91	1.082	18.18	16.20	15.06	1 14	1.082	25
26	......	......	1 060	......	12.45	9.80	2 65	1.060	100
28	Not det'd	16 60	1 073	......	14.68	12 83	1.85	1.073	75
Oct. 1	......	......	1.072	......	14.62	12.94	1.68	1.072	82
3	......	......	1 061	......	12.61	9.88	2 73	1.061	76
4	6.16	8.62	1.066	14.78	13 54	11.46	2.08	1 066	74
7	9.94	4.16	1.969	14.10	14 11	12.30	1 81	1.069	75
8	5.27	5.16	1 052	10.43	10.82	7.64	3.18	1 052	43
9	Not det'd	7.57	1 076	......	15 13	13.66	1.47	1.076	68
10	......	......	1.062	......	12 75	10.24	2 51	1.062	73
11	......	......	1 070	......	14.43	12 59	1.84	1.070	82
14	Not det'd	10.42	1 075	......	15.18	13 47	1.71	1.075	67
15	......	......	1.062	......	12 75	10 24	2.51	1.062	73
16	......	......	1.071	......	14 35	12.54	1.81	1 071	89
17	......	......	1.074	......	14.91	13 22	1.69	1.074	75
18	Not det'd	7.57	1 061	......	12.61	9.88	2.73	1 061	76
19	Not det'd	9.22	1.063	......	12.81	10.16	2.65	1.063	84
20	......	......	1.071	......	14 35	12.54	1.81	1.071	89
22	Not det'd	8.30	1.067	......	13.79	11.80	1.99	1.067	69
23	5.50	11.30	1 075	16.80	15 18	13.47	1.71	1.075	67
24	Not det'd	8.63	1.068	......	13.81	11.84	1.97	1.068	56
						247.56	43 52		
				Average	of (21)	11.79	2.07		

After the first analysis, under date September 18th, the results, as will be seen, are widely different. In explanation of this, Dr. Goessmann has given ample reason in his report accompanying these analyses. In regard to these early analyses (before September 18th) he says, the juice from the freshly cut canes grown upon the grounds of the Agricultural College, was "treated without delay;" and of those subsequent to September 18th he says: "A part of our cane, after being cut, was left upon the field for about ten days before being ground and pressed."

He says, that the results of these experiments "admit of no other explanation, but that the best course to pursue consists in grinding the matured cane as soon as it is cut."

In regard to the remainder of the experiments recorded by him, he says:

Some of the cane sent on (by farmers growing it near the college) was ground soon after it had been cut; other lots had been cut weeks before their turn in the mill came round.

It will be observed, then, that only those analyses made previous to September 18th, are of freshly cut cane; and these analyses fully agree with the average of my results with all the varieties of sorghum experimented with.

It will be observed, also, that, just as he found in those canes which were brought in some days (or even weeks) after they had been cut, so, too, my results show the inversion of a large amount of sugar; and, except in the sum of the sugars present in the juices, these results are not at all comparable with those secured by analyses of juices of the same specific gravity from freshly cut canes. It will also be of interest to remember, that the last examinations made by Dr. Goessmann of the canes grown under his supervision, were made only nine days after he describes the "seeds as still soft;" and, by reference to the tables, p. 000, it will be seen that, during each of the past four years, I found that it is just at this period of development of the plant that the sugar in the juice becomes practically available, and that thereafter it rapidly increases in quantity.

Inversion of Sugar in Cut Canes.

The effects of this inversion of sugar, due to allowing the cut canes to remain some time before working, will be seen in the following results with three varieties grown on the department grounds and promptly worked; these same varieties grown by Mr. Golden and not promptly worked; and three of the results of Dr. Goessmann, of which three he reports that the first analysis was of canes which, "after being cut, were left for three weeks upon the field," the second analysis of "cane several weeks old when ground," the third analysis of canes topped, cut up, and "left upon the field nine days." These are the only cases mentioned in his report in which the time is given during which the canes, after being cut up, remained unworked.

The close agreement of results attained with those from Mr. Golden's canes is obvious, and the great difference between these and the results from canes promptly worked up, show the great importance of

this matter to those hoping for good results in the production of sugar.

INVERSION OF SUGAR BY CANES NOT BEING WORKED PROMPTLY.

Varieties.	Department ground.				Mr. Golden.				Dr. Goessmann.			
	Specific gravity.	Sucrose.	Glucose.	Total Sugars.	Specific gravity.	Sucrose.	Glucose.	Total sugars.	Specific gravity.	Sucrose.	Glucose.	Total sugars.
Early Amber,...	1.087	16.06	1.38	17 44	1.063	3.75	10.85	14.60	1.082	6.27	11.91	18.18
Early Golden....	1.088	15.93	1.37	17.30	1 069	3 66	11 69	15.35	1.075	(?)	10 42	......
White Liberian.	1.083	16.03	1.37	17.40	1.070	2.30	13 25	15.55	1.052	60	10.00	10.60

It is possible that there may exist certain conditions of climate and crop, when the cane may be kept even weeks after cutting without great loss of sugar, but the above experiments conclusively prove that such a course is extremely hazardous, and that the only safe course to follow, is to work the cane as soon after cutting it (never more than twenty four-hours) as possible. In harvesting the sorghum, it is often the case that those stripping the cane may get ahead of those cutting, or the mill in pressing the cane, and it is to be remembered that so soon as the plant has been mutilated by stripping off the leaves, or by being broken down by the wind, there is opportunity for the air to have access to the juices of the cane, as is the case in cutting it up, and that fermentation and consequent inversion of the sucrose is liable to at once begin.

A single experiment appears to have been recorded, showing this effect, by Professor Swenson.

Effect of Leaving Cane Stripped in the Field.

One part of a patch of Minnesota Early Amber cane was stripped of leaves and left standing in the field from September 15th to September 22nd. It was then cut, and the juice, together with some that had not been stripped, was analyzed, with the following result:

	Cane sugar.	Glucose.
Cane stripped for one week................	11.05	3.25
Same cane not stripped.	12.98	2.78

The diminution of sugar is undoubtedly due to the fact, that the latent leaf buds found under each leaf begin to develop into new leaves. These new leaves are formed partly at the expense of the sugar in the cane.

The following analysis is given by Messrs. Scovell and Weber, showing, that little if any inversion could have taken place in the cane while standing two weeks in the field, after having been stripped:

Effect of Stripping and Allowing to Stand.

On October 2nd, 1880, an analysis was made of the juice of cane which had been stripped on the 18th of September—the cane not otherwise disturbed—with the following result:

Specific gravity of juice		1.074
Grape sugar	per cent	1.82
Cane sugar	per cent	13.11

This subject needs further investigation.

THE IMPORTANCE OF AN EVEN CROP, WITH NO SUCKERS, IN THE PRODUCTION OF SUGAR.

The experiments at the Department of Agriculture, in 1881, have fully confirmed the practical wisdom of a course which is pursued by the sugar planters of Louisiana and Cuba, viz., the exclusion from the matured crop of all immature canes, if the production of sugar is contemplated.

This point, if previously recognized by sorghum growers, has never been properly understood and considered as it deserves to be.

Danger from Suckers.

It is important also to remember that, owing to the tendency of sorghum to send up suckers from its roots from time to time during the season, there is the liability of having in the crop canes of every stage of development, and the injurious effect already shown is sure to result. It is, therefore, necessary, in order to secure the best results in the production of sugar, to see to it that either the growth of these suckers be prevented, by removing them from time to time during the season, or that they be thrown aside when the crop is harvested as worthless, except for the production of syrup.

To demonstrate this point, the plat of sorghum, grown upon the grounds of the Department of Agriculture at Washington, in 1881, and containing 34 varieties, was divided into two nearly equal parts, one portion of which was carefully kept free from suckers through the season, and the other portion, after having been thinned out like the former, was allowed to send up any suckers which would grow; and, when harvested, these suckers were included in the crop, weighed, stripped, and worked with the other stalks of the unsuckered portion.

The difference in the results of the above treatment is manifest in the following table, which gives the weight of crop, and the analyses of the juices from the suckered and unsuckered canes:

COMPARATIVE RESULTS FROM SUCKERED AND UNSUCKERED SORGHUM.

VARIETY.	No.	Weight of stripped stalks per acre, pounds.		Per cent of juice.		Specific gravity of juice.		Per cent glucose in juice.		Per cent sucrose in juice.		Per cent solids not sugars in juice.		Per cent available sucrose in juice.	
		Suckered	Not suckered.	Suckered	Not suckered.	Suckered	Not suckered.	Suckered	Not suckered.	Suckered	Not suckered.	Suckered	Not suckered.	Suckered	Not suckered.
Early Amber	1	21,074	24,757	45.4	48.4	1.087	1.088	1.38	2.52	16.06	15.56	3.81	0.99	10.87	12.05
Early Golden	2	23,201	34,667	48.3	46.3	1.088	1.085	1.37	2.07	15.93	16.52	3.93	1.69	10.63	12.76
White Liberian	3	17,006	26,426	43.1	48.6	1.083	1.080	1.37	1.62	16.03	14.62	3.46	4.45	11.20	9.61
White Liberian	4	15,329	29,512	47.5	50.7	1.098	1.079	1.27	1.67	15.81	13.60	4.27	4.55	10.27	7.38
Black Top	5	22,848	33,603	50.5	......	1.074	1.070	1.22	3.50	13.10	9.76	3.78	6.17	8.10	0.09
African	6	16,327	21,110	46.3	52.5	1.074	1.067	1.97	2.87	12.89	10.29	3.11	5.32	7.81	2.22
White Mammoth	7	33,333	27,373	50.9	49.3	1.078	1.074	1.35	3.79	13.96	11.76	2.91	4.46	9.70	3.51
Oomseeana	8	17,852	18,599	48.1	50.9	1.075	1.069	1.72	4.73	12.83	10.06	2.93	3.49	8.18	1.84
Regular Sorgho	9	21,383	21,194	51.6	51.0	1.071	1.056	2.91	3.59	11.08	7.33	2.72	4.79	5.45	—1.05
Link's Hybrid	10	33,041	28,936	49.8	51.1	1.086	1.067	0.80	1.86	16.29	12.08	......	2.64	15.49	7.58
Link's Hybrid	11	29,766	29,702	41.0	52.7	1.087	1.062	0.66	1.33	16.78	13.06	3.02	2.63	13.10	9.10
Sugar Cane	12	32,103	30,161	48.8	53.0	1.088	1.066	0.74	1.46	16.76	11.94	3.18	2.78	12.84	7.70
Goose Neck	13	18,045	22,086	51.5	56.2	1.076	1.050	2.39	4.07	12.62	6.35	2.97	2.29	7.26	—0.01
Bear Tail	14	20,461	21,252	46.9	48.8	1.074	1.065	3.16	2.41	12.58	10.92	2.32	5.35	7.10	3.16
Iowa Red Top	15	20,643	21,856	53.1	49.9	1.074	1.075	1.74	1.45	13.82	14.63	2.17	7.21	9.91	5.97
New Variety, Stump	16	24,486	29,294	45.2	45.7	1.079	1.068	1.71	1.90	14.21	12.67	2.98	2.75	9.52	8.02
Early Orange	17	30,634	31,079	53.4	44.1	1.078	1.065	1.92	3.69	13.92	10.57	2.38	2.12	9.62	4.76
Early Orange	18	20,447	23,584	48.2	39.8	1.081	1.064	2.48	3.38	14.12	13.57	2.41	......	9.23	10.19
Orange Cane	19	26,252	30,831	50.0	42.7	1.078	1.067	2.27	3.35	13.81	10.95	2.28	2.42	9.26	5.18
Neeazana	20	21,915	26,244	47.3	41.3	1.075	1.063	2.84	3.80	12.10	9.94	2.31	2.72	6.95	3.42
Wolf Tail	21	30,683	33,707	50.0	44.2	1.077	1.068	1.33	1.87	14.11	11.67	2.75	3.54	10.03	6.26
Gray Top	22	27,979	30,934	50.2	44.6	1.071	1.052	2.62	3.08	11.48	......	2.30	9.90	6.56	......
Liberian	23	27,700	29,040	50.2	44.6	1.071	1.059	5.07	4.24	9.27	8.18	2.23	3.16	1.97	0.78
Mastodon	24	33,538	29,941	52.9	51.3	1.062	1.051	2.31	3.09	10.30	8.24	2.14	4.22	5.88	0.93
Honduras	25	24,480	34,447	56.5	54.5	1.057	1.062	5.02	5.06	7.25	8.47	1.73	3.74	0.50	—0.33
Sugar Cane	26	17,215	19,677	49.8	51.4	1.063	1.053	3.52	3.49	9.72	6.15	1.90	3.27	4.30	—0.61
Hybrid No. 4	27	17,184	26,036	55.0	51.6	1.056	1.053	5.09	4.27	7.19	5.68	1.87	2.96	0.23	—1.55
White Imphee	28	19,382	18,525	50.2	54.6	1.068	1.041	1.55	1.62	13.52	5.45	2.06	3.01	9.91	0.82
Goose Neck	29	10,750	18,125	49.1	55.8	1.063	1.044	2.43	3.35	11.21	3.98	2.44	3.30	6.34	—2.67
White African	30	19,446	21,058	48.8	51.9	1.066	1.070	1.52	1.31	11.92	11.38	2.83	3.82	7.57	6.22
West Indian Sugar Cane	31	24,418	23,582	47.2	52.4	1.069	1.072	1.95	4.37	15.57	11.03	3.66	1.85	9.96	4.81
Sugar Cane	32	16,128	12,717	53.1	50.0	1.070	1.055	2.86	3.63	12.27	7.58	2.86	2.06	6.55	1.89
New Variety, X Lib. and Oom.	33	13,800	17,099	37.9	49.9	1.082	1.070	1.84	3.75	14.70	11.26	3.33	1.99	9.53	5.52
Minnesota Early Amber	34	16,977	19,877	46.2	52.1	1.078	1.077	1.56	1.91	14.82	13.96	3.33	2.56	9.93	9.49
Total		765,826	870,031	1,664.0	1,646.9	36.557	36.007	72.97	100.33	447.83	348.21	102.37	118.20	281.75	125.05
Average		22,525	22,589	48.9	49.9	1.075	1.059	2.14	2.95	13.17	10.55	3.10	3.58	8.29	3.79

From the preceding table, it will be seen that, while the average crop was the same from the suckered and unsuckered plats, and the percentage of juice also practically the same, the composition of the juice varied very widely, and, in every particular, was strongly in favor of the suckered stalks, so far as the production of sugar is concerned.

The average results of the thirty-four varieties show the relative composition of juices to be as follows:

	Suckered.	Unsuckered	Ratio.
Specific gravity..........per cent..	1.075	1 059	100 : 78.7
Sucrose.......... " ..	13 17	10.55	100 : 80 1
Glucose.......... " ..	2.14	2 95	100 : 137.9
Solids.......... " ..	3 10	3 58	100 : 115.5
Available sugar.......... " ..	8 29	3.79	100 : 45.7
Stripped stalks, per acre..........pounds..	22,525	22,589	100 : 100 3
Juice..........per cent..	48.9	49.9	100 : 102 0

It will be seen that, although there is a much greater amount of glucose and solids in the juice of the unsuckered canes, the specific gravity is less, and the sucrose is a fifth less, while the available sugar is only 45.7 per cent of the amount present in the juice of the suckered stalks.

By reference to the table it will be seen, that several of the varieties show no difference between the suckered and unsuckered portions, while in fact, some of them, as Nos. 1, 2, 18, show an amount of available sugar greatest in the juice of the unsuckered canes. The explanation of this is probably that, owing to the fact that these varieties had so long reached maturity, while the more advanced suckered canes had begun to fall off in their content of sugar, the unsuckered portions of the cane were largely composed of suckers, which had themselves had time to reach their complete maturity, and, consequently, they had brought up the average of the juice, rather than to have lowered it.

It is also to be observed, that, in the case of several of these varieties, we have results fairly comparable with what might be expected upon a large scale; for, although, as has been already stated, the analyses made during the season in the laboratory were of stalks taken from the suckered portion of each variety, and although exactly one-sixth part by actual weight, on an average, was taken from each variety, and that, whenever a stalk was cut down there would spring up suckers in its place, which were included in the final cutting, generally, as we have seen, with the effect to lower the average sugar content, it is yet true that many of these, as we may term them, culled rows, gave averages

in sugar fairly comparable with the average results from our Louisiana sugar-cane.

The average of Nos. 1, 2, 3, 4, 10, 11, 12, in available sugar, is 12.53 per cent of the juice. The average crop of stripped stalks per acre actually obtained of these seven varieties was 26,667 pounds.

A good mill would give 60 per cent of juice, or 16,000 pounds, and 12.53 per cent of this amount would give 2,005 pounds of sugar per acre, as the average product to be expected from the results obtained.

The following table gives the results obtained in working up the juices from these several lots of suckered and unsuckered sorghums, and the available sugar produced from each in the syrups, as also the available sugar present in the juices, for purpose of comparison.

By available sugar, is meant the difference between the sucrose and the sum of the glucose and other solids. Sucrose—(glucose, plus solids not sugar)=available sugar.

It will be seen that the average available sugar from the thirty-four varieties of sorghum which were suckered was 8.29 per cent of the juice; while from the unsuckered plat the average of thirty-seven varieties was only 3.9 per cent of the juice. Also, that while the former gave syrups averaging in available sugar only 32.17 per cent of their weight, the latter gave syrups averaging in available sugar only 18.71 per cent of their weight, or 58.2 per cent of the former. It will also be remembered, that the amount of stalks grown per acre was practically the same, whether the crop had been suckered or not. Also, that the suckered portion had been, during the season, culled of exactly one-sixth of its weight of stalks for purpose of analysis, and that these stalks, after being cut, sent up numerous suckers, which really lowered the average per cent in available sugar which would have been otherwise attained.

PER CENT OF AVAILABLE SUGAR IN JUICES OF SORGHUMS AND IN SYRUPS.

No.	VARIETIES.	DEPARTMENT GROUNDS.			
		Suckered.		Unsuckered.	
		Juice.	Syrup.	Juice.	Syrup.
1	Early Amber	10.87	......	12.05	......
2	Early Golden	10.63	......	12.76	......
3	White Liberian	11.20	......	9.61	......
4	do	10.27	......	7.38	28.16
5	Black Top	8.10	......	.09	......
6	African	7.81	35.90	2.22	......
7	White Mammoth	9.70	......	3.51	23.90
8	Oomseeana	8.18	......	1.84	......
9	Regular Sorgho	5.45	......	—1.05	16.19
10	Link's Hybrid	15.49	......	7.58	......
11	do	13.10	......	9.10	21.56
12	Sugar Cane	12.84	......	7.70	......
13	Goose Neck	7.26	......	— .01	6.26
14	Bear Tail	7.10	......	3.16	......
15	Iowa Red Top	9.91	35.18	5.97	35.12
16	New Variety	9.52	......	8.02	......
17	Early Orange	9.62	......	4.76	......
18	do	9.23	......	10.19	......
19	Orange Cane	9.26	......	5.18	......
20	Neeazana	6.95	......	3.42	18.30
21	Wolf Tail	10.03	......	6.26	......
22	Gray Top	6.56	......	......	......
23	Liberian	1.97	37.40	.78	6.36
24	Mastodon	5,88	......	.93	......
25	Honduras	.50	......	— .33	4.60
26	Sugar Cane	4.30	......	— .61	......
27	Wallis Hybrid	.23	......	—1.55	......
28	White Imphee	9.91	......	.82	......
29	Goose Neck	6.34	20.20	—2.67	......
30	White African	7.57	......	6.22	25.06
31	West India	9.96	......	4.81	......
32	Sugar Cane	6.55	......	1.89	......
33	New Variety	9.53	......	5.52	......
34	Early Amber	9.93	......	9.49	......
35	Holcus Saccharatus	......	......	— .94	......
37	Holcus Cernus	......	......	9.70	......
38	Honey Cane	......	......	6.71	20.34
42	Honduras	......	......	......	......
50	Neeazana	......	......	......	......
51	Liberian	......	......	......	......
	Average	8.29	32.17	3.90	18.71

The suckering then of the crop, or at least the careful exclusion of suckers from that portion of the cane which is intended to be worked for sugar, is of the most imperative importance.

For sugar production they are far worse than worthless.

But they may be used for the manufacture of syrup, since both glucose and sucrose enter into its composition; and, in fact, the presence of the suckers in the crop would very easily prevent the crystallization of the syrup which the manufacturers of syrup frequently find a serious disadvantage.

It is not shown that the growth of suckers has any injurious effect upon the cane, their presence being largely due to the rank growth of

the crop on strong soils, and in favoring circumstances, and it is not advised that they be thrown away, but that they only be used in the manufacture of syrup.

EFFECT OF REMOVING SEED DURING DEVELOPMENT OF PLANT.

During the experiments upon sorghums grown on the grounds of the Department for the past five years, much annoyance has been occasioned by the multitude of English sparrows, and it was almost impossible to save any seed from the crop, except of such varieties as appeared less attractive to these birds, or from such panicles as were protected against their invasions. It was at least a matter of doubt whether this removal of the seed during the plant's development had not had an effect upon the sugar content of the juices, since, as is obvious, the production of the seed is at the expense of constituents of the juice of the plant; and if this process is arrested by any removal of the seed before reaching maturity, it would appear natural to expect some result upon analysis of the juices of such plants.

That such a view has widely obtained, among those engaged in the investigation of the production of sugar from sorghum and maize stalks, is clear from the advice frequently given to remove the ears of corn so soon as they appear, if the maximum amount of sugar in the juice from the stalks is desired.*

For the purpose of securing the seed of the new varieties from Africa, India, and China, as also to learn whether to any extent my results in past years had been vitiated by these depredations of the birds, care was taken, in 1882, to protect certain panicles of each variety grown, so soon as they came into blossom, by enveloping them in bags made of tarlatan. In this way I was able to secure well developed heads of each, fully set with seed.

* Professor Weber reports the following analyses made of two stalks of sorghum, which had been planted at the same time; but the one, A, had been topped while it was in blossom, while B, had been allowed to retain the panicle, and the seed was in the condition of "hardening dough:"

A. Sucrose, 12.62 per cent, Glucose, 2.58 per cent.
B. Sucrose, 7,80 per cent, Glucose, 4.80 per cent.

There was a corresponding increase in specific gravity.

This is an important result, and apparently indicates that the production of the highest content of sugar is incompatible with the production of grain; and since the grain is alone sufficiently valuable to pay all the expense of cultivating the crop, it will be admitted, as most desirable, that this question, as to the practicability of the two crops of grain and sugar, be set at rest by decisive experiments.

In the examinations made there were taken for analysis one stalk, the panicle of which had been thus protected, and another at the same time, of the same variety, and, so far as other indications showed, at the same stage of development, but the seed of which had been taken by the birds.

There were made during the season, in all, 136 pairs of analyses of most of the varieties under examination. The results of these analyses are given in the following table.

In the first table there are given 92, and in the second 44, pairs of analyses.

It will be observed, that in the 92 pairs there is a result indicating an earlier stage of development in those stalks upon which the seed was kept, while in the 44 pairs this difference is not marked.

EFFECT OF REMOVING SEED.

	Seed removed.	Seed on.	Per cent.	Seed removed.	Seed on.	Per cent.
Stage of development ..	10 42	8 75	84.0	11 57	10 36	89 5
Per cent juice..............	55.775	58.063	104.1	56.569	56.488	99.9
Specific gravity............	1.0717	1 0607	84 7	1 06614	1.0673	101 7
Per cent glucose..	.968	1.403	144 9	1.207	1 083	89 7
Per cent sucrose....	12.659	9 958	78 7	11 336	12.076	106 5
Per cent solids........... ..	2 978	2 945	98 9	2 983	2 725	91 3
Polarization..........	12.734	9 883	77 6	11 484	11 864	103 3
Per çent available sugar...	8.650	5.670	65.5	7.076	8.342	117.9
Number of analyses.... ...	92	92	....	44	44	....

In the third and sixth columns is given the per cent of the average results secured from the analyses of those canes with full seed heads, of the average results obtained from the analyses of those canes from which the seed had been removed. It will be observed, that in the average results of 92 pairs there is an increase in juice of 4.1 per cent, and of glucose 44.9 per cent, and a decrease of every other element of the analyses: of sucrose, 21.3 per cent; of solids, 1.1 per cent; of available sugar, 34.5 per cent; and a decrease in specific gravity. It is also noticeable that, while the average stage of development was about midway between the tenth and eleventh in those stalks from which the seed had been removed, it was below the ninth stage in the stalks of which the seed had been protected.

The averages from the 44 pairs give results indicating almost the opposite effect, for it will be noticed that, although the tendency of the removal of the seed is to hasten the development and maturity of the plant, the average amount of juice and its specific gravity is practically the same; the amount of sucrose is greater, and that of glucose much less, the solids also being less, so that the per cent of available

sugar is increased 17.9 over that present in those juices from stalks not bearing seed.

The practical conclusions from these results are, that there is no incompatibility between the maximum crop of ripe seed possible, and the maximum content of sugar in the juice of the stalks; and that, owing to the more rapid development of the cane from which the seed has been removed, the time necessary from planting to the maturity of the crop would be shortened from seven to ten days for each of the varieties, if the seed was removed early.

By comparing the average results above given, it will be seen that in the one case the stalks with the seed on had not yet attained their maximum, while in the other case they had done so, and those with which they were compared, being without seed, had attained their maximum sometime before, and had retained it until the others had caught up with them in their sugar content.

It is also to be observed, that those varieties in the first case where the difference was so much in favor of the stalks without seed, were largely the later maturing kinds, while in the second case the varieties are chiefly those maturing earlier.

An average of the number of days required from planting to maturing, as shown by the experiments of 1882, gives for the varieties of the first lot 120 days, and for those of the second lot 112 days, thus confirming the conclusions above given.

EFFECT OF STRIPPING CANE.

On account of the trouble in stripping the stalks, experiments were made, in 1879, with stalks unstripped, the tops alone being removed; and these experiments appear to prove that this troublesome operation of stripping may be avoided without any diminution of the amount of juice or of sugar obtained therefrom.

Below are the results obtained from stripped and unstripped sorghum, calculated to the raw stalks used.

By raw stalks is meant the stalks as they were cut in the field, leaves, tops, and all.

	Average per cent of juice to raw stalks.	Average per cent syrup in juice.
Stripped sorghum (two experiments)	35 02	15 00
Unstripped sorghum (five experiments)	40.60	15.47

From the above it will be seen, that not only was an increased amount of juice obtained, but that this juice gave an increased percentage of syrup, and there appears nothing unusual in the treatment of this juice from the unstripped cane, nor was there any appreciable difference in the readiness of the syrup to crystallize, nor in the character of sugar finally obtained.

At the time of these experiments, the mill used was an old one, and the amount of juice expressed much less than should have been obtained; but recent experiments seem to show that the conclusions from those experiments were fully justified. Those conclusions were as follows:

Although perhaps further experiments are desirable before considering this point as settled, it would appear from the above that not only was stripping unnecessary, but that it really involved a loss in the amount of sugar to be obtained; at least the above results indicate a difference of twenty per cent increase in product of syrup in favor of the unstripped cane. It is not improbable that the above result is due to the fact, that the leaves in passing through the mill tended to fill up the interstices between the compressed cane, and thus prevented the expressed juice from flowing through between the rolls with the bagasse. In case of discoloration by action of moisture or other causes, it will, however, be advisable, and probably necessary, to strip the stalks.

Mr. Shoemacker, West Salem, Wis., reports as the result of three experiments, that "all three were in favor of unstripping."

Henry Lindley, of Mazomanie, Wis., reports as the result of his inquiries, that pressing with the leaves on make no difference in either the quality or quantity of the syrup produced.

Another manufacturer reports to the Wisconsin Cane Growers' Association, that he never strips his cane, and finds no trouble in making good syrup. Is unable to see any difference in the syrup, from stripped and unstripped cane.

It is customary to deduct 200 pounds from each ton, for leaves when the cane is unstripped, and then allowing the same price for the cane, whether stripped or not.

At the Champaign Sugar Works, Illinois, they did not strip the cane.

At Rio Grande, New Jersey, they did not strip any of their cane, and they found no trouble crystallizing their syrup in the vacuum pan.

In fact, there is no doubt but that the amount of juice which a given lot of cane will yield, is appreciably greater if the cane is

passed through the mill with the leaves on, than if it is stripped; but owing to the fact that the juice from the leaves is impure, containing an excess of glucose and solids, it is found that the presence of the leaves on the cane causes a gain of about 6⅓ per cent in the amount of syrup, and a loss of about 6⅔ per cent in the amount of sugar to be obtained.

This matter will be again discussed at another place, page 144.

In those cases where the sorghum was stripped and topped, the following percentage of stripped stalks, and of leaves and tops, was obtained:

Sorghum.	Per cent of stripped stalks.	Per cent of leaves and tops.
First experiment	72.67	27.33
Second experiment	72.55	27.45
Average	72.61	27.39

In 1882, as the average of eight experiments, the relative weight of stripped stalks to leaves was as 100 to 17.68, this would give the amount of leaves as 15 per cent of the topped stalks.

Comparative Analyses of Juices from the Stalks and Leaves of Sorghum.

Owing to the trouble and expense involved in stripping the canes for the mill, the following analyses were made for the purpose of determining the effect of leaving the cane unstripped. In the eight experiments below recorded, the stalks were topped as usual, and the blades from each lot weighed, passed through the mill, and the juice expressed. The juices from stalks and leaves were then analyzed as usual.

In the Annual Report Department of Agriculture, 1879, page 59, it will be seen that, as the result of seven experiments, two with stripped and five with the unstripped stalks of sorghum, there was an increase of juice calculated to the raw stalks (*i. e.*, to stalks as cut in the field without topping or stripping). This would indicate that stripping was not necessary, and actually resulted in loss of syrup, if not in sugar. To more fully determine this, the above-mentioned experiments were made, and the results are given in the following table:

COMPARATIVE ANALYSES OF JUICES FROM THE STALKS AND LEAVES OF SORGHUM AT DIFFERENT PERIODS OF DEVELOPMENT.

Condition of plant.	No. of experiment.	Weight of stripped stalks.	Weight of leaves.	Per cent of juice from stripped stalks	Per cent of juice from leaves.	Pounds of juice in stalks.	Pounds of juice in leaves.	Specific gravity of stalk juice.
		Lbs.	*Lbs.*					
Suckers	1	10 23	4 75	62 02	37 03	6.344	1.759	1.022
In bloom	2	7 81	1 73	64 00	25 00	4 998	.433	1.047
After bloom	3	6 85	1 54	67 89	26 64	4 650	.410	1.051
Seed in milk	4	7.58	1 35	64.67	27.77	4.900	.374	1 059
Seed in dough	5	7.25	1.07	62 61	26.40	4 539	.282	1.070
Sucker seed in dough	6	13.02	1 91	62 27	26.86	8 108	.513	1.068
" "	7	11 18	1 96	60 32	27.86	6 744	.546	1.072
Sucker seed, hard	8	16 34	2 80	54.09	34 83	8 838	.975	1.061
" "	9	12 70	2 13	62.35	34 61	7.918	.737	1.074
Sucker seed in milk	10	18.02	3 70	61.31	34 25	11.048	1.267	1 074
Sucker seed in dough	11	14.49	2.90	57.55	32 43	8.339	.941	1.075
" "	12	13 41	2.34	57.89	35 12	7.763	.822	1.068

Condition of plant.	Specific gravity of leaf juice.	Per cent of glucose in stalk juice.	Per cent of sucrose in stalk juice	Per cent of solids not sugar in stalk juice.	Per cent of glucose in leaf juice.	Per cent of sucrose in leaf juice.	Per cent of solids not sugar in leaf juice.
Suckers	1.025	.66	2.04	2.53	.27	1.40	4.45
In bloom	1 040	4 48	5 67	2.25	2.29	2 93	5 27
After bloom	1 042	8 74	2.22	2 14	3.08	1.32	6.24
Seed in milk	1 047	10 29	3 21	1 84	2 84	1.66	7 82
Seed in dough	1 051	14 64	1.87	1 54	2.15	1.52	9.21
Sucker seed in dough	1.056	11 79	1.15	3.03	4 23	2 25	6 76
" "	1.049	13 31	.93	3 28	2.33	2.50	7 71
Sucker seed, hard	1.053	12 18	1.06	1 57	3.36	2.04	6.09
" "	1.044	13.83	.98	2.65	2.20	2.29	7 00
Suck seed in milk	1.044	14.27	.69	2 71	2.58	1 22	6 29
Sucker seed in dough	1 048	13 00	1.75	3.79	2.53	3 50	4.10
" "	1.056	11.81	.94	3.07	2.25	1.89	13 25

Condition of plant.	Per cent of total solids in stalk juice.	Per cent of total solids in leaf juice.	Per cent of available sugar in stalk juice.	Per cent of available sugar in leaf juice.	Pounds of available sugar in stalk juice.	Pounds of available sugar in leaf juice.	Per cent of loss of available sugar with leaves.	Per cent of gain of syrup with leaves.
Suckers	5.23	6.12	—3.91	—5 58	—.2481	— 0982	...	32 4
In bloom	12 40	10.49	—3 44	—5 91	—.1720	—.0256	.....	7 3
After bloom	13.10	10.64	4 38	—4 48	.2037	— 0185	9.1	7 1
Seed in milk	15.34	12.32	5 24	—6 64	.2568	—.0249	9 7	6.2
Seed in dough	18.05	12 88	11 23	—8.58	.5098	—.0242	4 8	4.4
Sucker seed in dough	15 97	13.24	7 61	—4.78	.6170	— 0245	4 0	5.1
" "	17 51	12 54	9.10	—7.88	.6137	— 0430	7.0	5.8
Sucker seed, hard.	14.81	11.49	9.55	—4 77	.8440	— 0465	5.5	8.6
" "	17.46	11.49	10.20	—7.09	.8076	— 0523	6.5	6.1
Sucker seed in milk	17.67	10.09	10 87	—4.93	1.2009	—.0625	5.2	6.6
Sucker seed in dough	18.54	10.13	7.46	—5.07	.6221	—.0477	7.7	6.2
" "	15.82	17.39	7.80	-12 89	.6055	—.1060	17.5	11.6

The above results show, that the effect of stripping the cane is to diminish the quantity of juice, but to improve its quality. It has been almost invariably stated, that by leaving the blades upon the stalks a large amount of juice would be wasted.

Such is far from the case, but it is to be observed that in no case was there any available sugar in the juice from the leaves, owing not to the excess of glucose, but to the much larger percentage of solids not sugars in the leaf juice.

The general result, then, of putting the unstripped stalks through the mill is, as an average of the eight experiments, to occasion a loss of available sugar equal to 6.66 per cent of the amount found in the juice from the stalks, and to cause a gain of 6.33 per cent in the amount of syrup over that to be obtained from the juices of the stalks alone. This is due to the fact that the total sugars, with those solids not removed by defecation and skimming, go to increase the amount of syrup to be obtained from a juice.

Method of Stripping.

Owing to the value of the leaves as fodder, many may wish to strip their cane, if only to utilize this material.

In stripping, a wooden blade about three feet in length may be used, when, by two or three dextrous blows, the blades may be easily removed while the cane is standing. The seed heads may be removed by bending down under the arm a small bundle of the standing cane, and, by a blow of a sickle, several tops may be at once struck off.

In saving the seed, it may be gathered up in small handfuls and laid upon the ground to dry, care being taken to turn it every few days until it is dry and ready for threshing. It may be threshed in the ordinary machine used for wheat and like grain; but, after the threshing, great care should be taken to provide for its being thoroughly dried before it is put in bulk. By such means, the Rio Grande Sugar Company economically secured their large crop of seed in good condition.

Some criticism has been made against the use of machine threshed seed for planting, owing to the danger of its being broken up and its germinating power destroyed; but, of course, after testing the seed, more may be planted, if necessary, since the expense for seed is but trifling.

CHAPTER VI.

(*a.*) Effects of temperature and rain-fall on sorghum.
(*b.*) Effects of frost on sorghum.
(*c.*) Effects of fertilizers on sorghum.
(*d.*) Composition of soil as affecting sorghum.

EFFECTS OF TEMPERATURE AND RAIN-FALL ON SORGHUM.

Obviously the climatic conditions prevailing have the most important influence, not only upon the successful growing of the cane, but upon its content of sugar. This has been so conclusively shown true in the cultivation of sugar-cane and sugar beets, that it is of the greatest importance to determine what conditions are the most favorable for sorghum.

The ordinary farmer, with his time wholly taken up in the care of his crops and cattle, can hardly be expected to keep accurate data as to the temperature and rain-fall, although his success or failure may almost entirely depend upon these conditions. On the other hand, the climate, on the average, is pretty generally known for each section of the country, and if those observers who have the opportunity to make record of their work shall compare them, it will within a few years be ascertained in what sections of the country climate and soil conspire to produce the best results, and thus fix the localities where the production of sugar from sorghum may be most economically conducted.

Nearly all the results of the analyses of the various sorghums, given in these pages, have been secured at Washington, D. C., in the years 1879, 1880, 1881, 1882; and the following data from the records of the Signal Service Bureau of this city are, therefore, of the greatest value in the discussion of the results obtained, and it will be seen that many of the results are clearly explicable, by reference to this data alone.

The consideration of the soils will be taken up at the end of this chapter.

In this connection, the following passage from "Sugar Growing and Refining," page 21, will be read with interest:

Climate has a very pronounced effect upon the commercial value of all plants whose secretion products are sought to be availed of, and the sugar-cane forms

no exception. This plant thrives to the greatest perfection in a warm, moist climate, with moderate intervals of hot, dry weather, tempered by refreshing sea breezes. Its most luxuriant development is always observed on islands and sea coasts, leading to the supposition that the saline particles conveyed to it by the winds are congenial to its taste; but, perhaps, a more weighty reason for the exuberance of the plant in such situations, is to be found in the moisture which accompanies the sea breezes, even in the hottest and dryest weather.

Again:

It is obvious that the sugar-cane is essentially a tropical plant, requiring the strong light and great heat which can only be found in the tropics. But these conditions alone are not sufficient for successful cane culture. Rain at the proper season is equally necessary, though it may be to a great extent replaced by a proper system of irrigation. On the other hand, rain at the wrong season, *i. e.*, when the canes are maturing, if in great quantity, may do much mischief. As the canes are approaching maturity, 2 or 3 months of hot and fairly dry weather are exceedingly beneficial, bringing the juice to the highest degree of sweetness, and assuring a large yield of fine sugar. Slight showers at long intervals, serve to maintain the vigor of the plant without appreciably weakening the juice. In the case of renewed vegetation being caused by rains after a drought, if it occurs in a locality where frost is not to be feared, it will sometimes be advantageous to leave the canes on the ground much later than usual, as the juice will gradually become richer than it can be immediately after the rain.

On the other hand, should an alternation of sunshine and rain, which for the space of 5 or 6 months has induced a luxurious vegetation, be followed by a long continued drought, the growth of the plants and rattoons will be prematurely checked, and they will often, under these circumstances, show a disposition to arrow. Should they now be cut, the juice will probably be found of good quality, and easily made into sugar—the only attendant evil being its deficiency in quantity, owing to the small size which the canes have attained. With a return of rain, vegetation would immediately revive, and then the evil of having juice poor in saccharine matter would be added to that of unusually small canes.

The above quotation, written with reference only to the sugar-cane, is almost a literal record of the results obtained at Washington with the many varieties of sorghum, and accords with the experience of many cultivators in various sections of the country.

TEMPERATURE AND RAIN-FALL, 1880, 1881, 1882.

MONTH.	1880.		1881.		1882.	
	Mean monthly temperature.	Average daily rain-fall.	Mean monthly temperature.	Average daily rain-fall.	Mean monthly temperature.	Average daily rain-fall.
	° *Fahr.*	*Inches.*	° *Fahr.*	*Inches.*	° *Fahr.*	*Inches.*
May	70.8	0.11	67.9	0 06	59.2	0 16
June	74.8	0.12	70 9	0 19	73 8	0 08
July	77.2	0 07	77.4	0 05	76 0	0.14
August	75.1	0.12	76.4	0.03	73 9	0.14
September	67 9	0.11	77 0	0 07	69.1	0 26
October	55 4	0.07	62 9	0.11	61.0	0.02
November	40.7	0.08	47.5	0.08	42.9	0.04
December, to 16th	....	....	....	....	34 1	0.06

HEAVY RAIN STORMS, MAY 1ST TO NOVEMBER 30TH, 1880.

Date.	Began.	Ended.	Amount.	Remarks.
			Inches.	
May 11th	4.34 p. m.	6.05 p. m.	1.40	All rain storms between the dates named, in which the amount of precipitation exceeded one inch, are here given.
June 14th to 16th	8.25 p.m., 14th	8.10 a.m., 16th	2 46	
July 22nd.	6 10 a. m.	4.10 p. m.	1 37	
August 3rd to 4th	4.20 p. m., 3rd	8.50 p. m., 4th.	1.89	
Septemb'r 6th to 7th	8.35 p. m., 6th.	5.00 a. m., 7th.	1 34	
Septemb'r 8th to 9th	6.15 a. m., 8th.	10.00 p. m., 9th.	1.53	

HEAVY RAIN STORMS, MAY 1ST TO NOVEMBER 30TH, 1881.

Date.	Began.	Ended.	Amount.	Remarks.
			Inches.	
June 27th	1.20 p. m.	8.45 p. m.	2 59	All rain storms between the dates named, in which the amount of precipitation exceeded one inch, are here given.
September 11th	4.30 p. m.	8.40 p. m.	1 33	
October 23rd to 25th	10.08 p. m., 23rd	8.05 a. m., 25th.	1.26	
Oct. 29th to Nov. 1st	2.25 a. m., 29th	10.15 a.m. Nov. 1st	1.69	

HEAVY RAIN STORMS, MAY 1ST TO DECEMBER 15TH, 1882.

Date.	Amount.	Date.	Amount.	Remarks.
	Inches.		*Inches.*	
May 27th	1 11	August 27th and 28th	1 21	All rain storms between the dates named, in which the amount of precipitation exceeded one inch, are here given.
May 31st to June 1st.	1.24	Sept. 3rd and 4th	1.54	
July 4th.	2.00	Sept. 11th	1.85	
July 28th to 29th	1.05	Sept. 20th and 21st	1 48	
August 1st to 2nd	1.48	Sept. 26th	1.15	

Frosts (fall of 1880)—October 1st, 19th, 25th; November 1st, 2nd, 3rd, 8th, 9th, 16th.
Frosts (fall of 1881)—October 6th and 11th; November 14th, 16th, 17th, 28th, and 29th.
Frosts (fall of 1882)—November 3rd, 5th, 6th, 15th, 16th, 19th, 21st, 22nd, 23rd, 24th, 26th; December 2nd, 4th, 12th.

	1880.	1881.	1882.
Total rain-fall, May and June .... Inches	6 89	.7 57	7.33
" " July, August, September.. "	9.37	4 93	16.74
" " May to September, inclusive. "	16.26	12 50	24.07
Average daily rain-fall, May and June "	.113	.124	.120
" " " July, August, September.. "	.102	.054	182
Average mean temperature, May and June .... Degrees F.	72 8	69 4	66 4
" " " July, August, September. "	73 4	76 9	73.0
" " " May to Sept'r, inclusive.. "	73.16	73.92	70.40

RAIN-FALLS.

1880.... 6 in all, May to September, inclusive, aggregating 9.99 inches.
1881.... 3 " " " " " 4.87 "
1882... 10 " " " " " 14.11 "

By reference to the above data it will be seen, that the past three seasons, covering most of the experiments in cultivation here recorded, have been very unlike in their climatic conditions.

Comparison of Seasons 1880 *and* 1881.

The crop returns for 1881, and universal testimony, agree that that season was, over a wide area of our country, of an almost unprecedented character. A cold, backward spring, and a drought of exceptional severity, united to produce most unfavorable results.

The records which follow will fully sustain the general opinion, and explain sufficiently the reasons of failure in sugar making.

It will be observed, that the average mean temperature for May and June, in 1880, was 72.8°, while, for the same months in 1881, it was 69.4°; also, that the total rain-fall for these months was, in 1880, 6.89 inches, of which amount 5.29 inches fell in three rains, pretty evenly distributed over the two months, viz: May 11th, 1.40 inches; May 22nd and 23rd, 1.61 inches; and June 13th, 2.28 inches.

On the other hand, in May and June, 1881, the total rain-fall was 7.57 inches, of which 5.71 inches fell in June.

Also, it will be observed that, during the three months of July, August, and September, in 1880, the mean average temperature was 73.4°, and the total rain-fall 9.37 inches; the mean average temperature for these months in 1881 was 76.9°, while the total rain-fall was only 4.93 inches, and of this small amount nearly half, 2.19 inches, fell in September.

The results, however, secured in the plat of sorghum planted on the grounds of the department, fully justify the reputation this plant has of being able to withstand drought, although it appears necessary to this end, that the crop should secure a good start before the drought. Such, as will be seen, was the case in the experimental plat above men-

tioned; for, although planted early (April 29th), the ground had been carefully prepared, had a good exposure to the sun, and the crop came forward rapidly, so that it was fully two feet high before the seed was planted for the third time in the larger fields.

In very marked contrast, were the results seen upon a portion of the department ground. A portion of the sorghum plat was plowed up through a mistake, and upon June 13th (forty-six days after the first planting), this portion was re-planted with ten varieties of sorghum. But neither of these varieties attained any development, the average not being even 10 per cent of the crop secured from the ground immediately surrounding this re-planted portion; and, throughout the season, these ten varieties were stunted, withered, sickly, and evidently the result of the drought which followed closely upon this planting, and before a good start had been made by the plants.

On the other hand, the several varieties grown upon the field from the first planting suffered comparatively little harm; and yet, although withstanding this severe drought during July and August, the result was evident in a much lighter crop than was secured in 1880, as will be seen by the following:

The average weight of stripped stalks per acre of thirty-eight varieties grown in 1880 was 31,409 pounds, the maximum being 50,017, and the minimum 13,839, pounds per acre.

The average weight of stripped stalks per acre of thirty-four varieties grown in 1881 was 22,524 pounds, the maximum being 33,538, and the minimum being 10,750, pounds per acre.

It is interesting to consider the meteorological data of 1880 and 1881, in connection with the results shown by the tables representing the average results of analyses for these years. It will be remembered, that the varieties of sorghum grown in 1880 and 1881 were mainly the same; the land upon which it was grown was the same; the mill by which the juice was expressed was the same, and care was taken to maintain it in good order. It will, however, be seen, that the average percentage of juice, by weight, obtained from the stripped stalks was greater in 1881 than in 1880—that in 1881 averaging 64.02 per cent, while that in 1880 averaged only 62 per cent.

It will be seen, also, that the specific gravity of the juices from the thirteenth to the nineteenth stage, inclusive (the period when the canes should be worked for sugar), differs greatly, the average specific gravity being, for this period, in 1880, 1.071, while in 1881 it was 1.078, this showing, as is seen by the analysis, the presence of a larger quantity of sugar in these juices of 1881.

The increase in specific gravity as will be seen, is due to the in-

creased amounts of sugar, and since the percentage of juice is about in the inverse ratio, it shows that the amount of water in the plant varies but very little, whether in seasons of rain or drought.

But the very general belief that the character of the juice undergoes great change, due to the occurrence of heavy rains, seems hardly to be supported by the facts. In fact, it would be of great importance if these opinions were more generally submitted to the test of experiment. If we look over the meteorological data from the Signal Office, which has just been given, we shall see that, on the 10th and 11th of September, 1881, there was a rain-fall of 1.73 inches, which succeeded a season of protracted drought. It would seem, then, in accordance with the generally accepted belief, that we should obtain evidence of this in a greatly increased percentage of juice; but an examination of the tables of analyses shows no appreciable change in either of the varieties.

AVERAGE RESULTS OF ANALYSES OF THIRTY-EIGHT VARIETIES OF SORGHUM MADE DURING THE WORKING PERIOD IN 1880 AND 1881.

	1880.	1881.
Per cent juice expressed	60.67	59.70
Specific gravity of juice	1.071	1.078
Per cent glucose in juice	1.98	2.01
Per cent solids in juice	3.34	3.09
Per cent sucrose in juice	12.14	15.02
Per cent sucrose available in juice	6.82	9.93
No. of analyses	1348	280
No. of varieties	38	38

It appears from the above, that there was, during the working period, on these thirty-eight varieties of sorghum, in 1881,

A loss of 1.6 per cent in the juice,
A gain of 9.9 per cent in specific gravity,
A gain of 1.0 per cent in glucose,
A loss of 7.5 per cent in solids,
A gain of 23.7 per cent in sucrose,
A gain of 45.6 per cent in available sucrose, over the results obtained in 1880.

The conclusion appears established, that if only the crop of sorghum shall have got fairly under way before the drought, there is no crop which more effectually withstands it—and the result is a crop of cane, less in the aggregate weight, but much richer in sugar than a crop grown under the conditions of moisture and temperature which, with maize, give the best results; for, it will be remembered that this season of 1881 was most unfavorable for maize, much of it being wholly lost.

The season of 1880 may fairly be regarded as an average of those of 1881 and '82, in Washington, in regard to temperature and rain-fall; while the season of 1881 was almost unprecedented for the severe drought.

The total rain-fall from May to September, inclusive, was only 12½ inches; while, during the same period in 1882, it was 24.07 inches. In 1881 the number of storms, during this period, was only three, with an aggregate rain-fall of only 4.87 inches; while, in 1882, there were ten storms, with an aggregate rain-fall of 14.11 inches. The average temperature for these five months (from planting to maturity of the crop) was, in 1881, 73.92° F.; while, in 1882, it was only 70.40° F.

It will also be observed that the first frost, in 1882, was (notwithstanding the unusually cold season) a month later than in the two preceding years.

The lack of rain during October, 1882, and a temperature, for the month, much above the average for the preceding two years, together with absence of frost, gave an additional month for the maturity of the sorghums; and this, in part, made up for the late planting and unfavorable season.

Effect of Rain upon the Composition of Sorghum Juices.

The investigation of this question, and the results secured, offer a good illustration as to the importance of submitting doubtful questions to the test of actual experiment; since it is nearly certain that any one, reasoning from *a priori* considerations, would have concluded (and, indeed, such conclusion has been accepted as established fact), that the effect of rain would be manifest in a diluted juice, and that, conversely, a prolonged drought would result in a concentration and diminution of the juice. The results, however, of very many experiments on every variety of sorghum, during the past season, prove the incorrectness of such conclusions.

Effect of Heavy Rain-fall after Long Drought.

For the purpose of showing the effect produced, if any, in the composition of the several sorghums, due to a heavy fall of rain, the following table has been prepared, which gives the results of analyses of each variety, taken before and after the heavy rain-fall of September 10th and 11th.

The average of the analyses of all the varieties, made just before the heavy rain of September 10th and 11th (viz., those made September 7th, 8th, and 9th), also the average of all the analyses of each

variety made immediately succeeding this rain-fall (viz., analyses made on September 12th, 14th, 15th, and 17th), and the results are as follows:

TABLE SHOWING EFFECT OF HEAVY RAIN-FALL AFTER LONG DROUGHT.

Variety, Row No.	DATES OF ANALYSES.	Analyses taken just before Sept. 10th and 11th.					Analyses taken just after Sept. 10th and 11th.				
		Sucrose.	Glucose.	Solids not sugar.	Juice.	Specific gravity.	Sucrose.	Glucose.	Solids not sugar.	Juice.	Specific gravity.
		Per cent.	*Per cent*	*Per cent*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	
1	Sept. 7, 17, and Oct. 5, 15....	18 23	.80	3 00	54.17	1.089	17.09	.86	3.64	43 83	1.088
2	Sept. 7, 17, and Oct. 5. 15....	17 41	.81	2 76	58 86	1 084	16 89	1 11	3.19	52.80	1.085
3	Sept. 7, 17, and Oct. 5, 15....	18 30	.86	1.77	63 51	1 087	16.88	1 05	2.88	53.72	1.086
4	Sept. 7, 17, and Oct 5, 15 ..	19 58	.95	2 75	59 51	1.095	15.24	1.27	3 86	50 54	1 080
5	Sept. 7, 17, and Oct. 5, 15....	14 08	2 03	2 32	64.45	1.074	17 01	.49	2 98	50.46	1 086
6	Sept. 7, 17, and Oct. 5, 15 ...	18.38	1 48	3.95	45 14	1 098	17.69	.57	3.12	59 30	1 087
7	Sept. 7, 12, and Oct. 7, 17....	16 00	1.73	2 40	62 01	1 083	15 65	1.62	1.52	63. 64	1.080
8	Sept. 7, 12, and Oct. 7, 27 ...	16.86	1 07	2.20	56 95	1 083	12 56	2.44	1.79	62.21	1 072
9	Sept. 8, 12, and Oct. 7, 17....	16 99	1.38	2 76	60 94	1.086	10.16	3.52	2.07	62.16	1 063
10	Sept. 8, 12, and Oct. 7, 17....	17.86	.83	3.39	57.69	1.089	18.18	.80	2 85	58 33	1.090
11	Sept. 8, 12, and Oct. 7, 17....	18.86	.66	3.33	54.59	1 094	17.03	1.03	2.56	59.56	1.086
12	Sept. 8, 14..................	16.12	.79	4 87	60 83	1.083	19 51	....	...	55.68	1 093
13	Sept. 8, 14..................	16 91	1.81	3.00	57.38	1 084	15.70	1.75	4 81	63 01	1.069
14	Sept. 8, 14..................	16.39	1.90	3.25	64.38	1 084	17.54	1.55	3.77	52.40	1.087
15	Sept. 8, 14..	16 93	1 26	3 88	58.16	1.087	18.28	.77	3 94	60 10	1 087
16	Sept. 8, 14, 19, and Oct. 17...	18.81	1 26	2 97	63.87	1 098	18.61	1 14	3.16	59 00	1.091
17	Sept. 9, 14, 27, and Oct. 18...	17 38	2 29	4 94	55 77	1 093	19 20	1 54	2 61	51.49	1 092
18	Sept. 9, 14, 27, and Oct. 18...	16.46	2 58	3 98	58 05	1 086	17.79	2.85	3.55	56.79	1.089
19	Sept. 9, 14, 27, and Oct. 18...	17 20	2 00	4 67	54.48	1 089	15 79	2 06	4.52	60 35	1 084
20	Sept. 5, 14, 27, and Oct. 18..	15.35	4 30	2 89	62.78	1.089	15.95	1.96	4.23	51.53	1 084
21	Sept. 9, 14, and Oct. 3, 12 ...	16 02	1 53	..	62.50	1.094	18.69	1 09	. .	59.77	1.690
22	Sept. 5, 15, and Oct. 3, 14...	14 40	3 00	3 06	61 71	1 080	13 96	1.93	5.05	59 53	1 075
23	Sept. 9, 15, and Oct, 3, 14....	13.00	4.71	3 65	67.62	1 081	14 23	2.94	4.14	59 04	1 081
24	Sept. 9, 15, and Oct. 3, 14....	14.27	1.51	2.51	66 00	1.073	11 31	2.64	5 03	60 07	1.064
25	Sept. 5, 15, and Oct. 3, 14....	13.45	3.26	1.92	67.92	1 073	14.23	2 55	5.43	59 56	1 076
26	Sept. 9, 15, and Oct. 3, 14....	9 80	5.18	4.40	59 53	1.073	11 14	3.73	3.82	63 11	1.070
27	Sept. 9, 15, and Oct. 3, 15....	13.05	4.16	2 28	62 78	1 077	11.65	3.82	3 68	62.24	1 070
28	Sept. 9. 15, and Oct. 3, 15....	19.25	1.48	2 41	61.06	1.089	16.73	.86	4.38	57.02	1.083
29	Sept. 9, 15, and Oct. 4, 15....	16 00	1 83	2 00	60 10	1.077	14.37	1.21	5 27	57.58	1.079
30	Sept. 9, 15, and Oct. 4, 15....	16 14	1.70	2.40	58 77	1 077	14.62	1 33	4 47	61.09	1 077
31	Sept. 9, 15..................	18 87	1.70	3 07	62.55	1 087	14.47	2.54	4.26	57.55	1 081
32	Sept. 9, 15.................	15 80	3.07	1.13	58.39	1.075	13 38	2.57	4.30	68.81	1 074
33	Sept. 9, 15................	15 13	2.72	2 33	61 72	1 075	14.70	2.14	3.28	58.64	1 076
34	Sept. 9, 15................ ..	15.90	1.38	2 68	57.33	1.077	11.52	1.87	5.04	62.83	1 066
37	Sept 7, 17....	12 57	99	4.19	32 36	1 073	13 61	.68	4.31	45 27	1 075
38	Sept. 7, 17..........	8.97	5.19	1.04	69.64	1.059	13.07	2.83	2.09	61.62	1.070
	Average...............	16.02	2.06	2.98	59.54	1.0832	15.40	1.803	3.694	57.80	1.0802

AVERAGE RESULTS OF ANALYSES OF THIRTY-SIX VARIETIES OF SORGHUM BEFORE AND AFTER THE RAIN-FALL OF SEPTEMBER 10TH AND 11TH.

	Before.	After.
Sucrose........ per cent..	16 02	15 40
Glucose........ per cent .	2.06	1 80
Solids........ per cent	2 98	3 69
Juice........ per cent..	59 54	57 80
Specific gravity........	1 083	1 080
Available sugar........ per cent	10.98	9 90

From the above it will be seen, that the results of this storm, as shown in these analyses, show an average loss of

	Per cent.
Sucrose........	3 9
Glucose........	12.6
Juice........	2 9
Specific gravity........	3.6
Available sugar........	9.8

The gain in solids was 23.8 per cent.

The above results are rather surprising, and certainly opposed to the view generally entertained. Without accepting them as wholly conclusive, it must be remembered that they are the results of a very large number of determinations, and of a very large number of distinct varieties. If it shall hereafter be shown that such a result invariably follows a rain-fall, it would appear that the explanation is, that, by such rain-fall, a vigorous growth in the plant is excited, and that the material for this rapid development of the plant is derived from the stored-up food (mainly sugar or starch) present. This would account for the loss in sugar; while the water, being simply the vehicle for transporting such food, is evaporated from the foliage more rapidly than it is absorbed by the roots.

The following report submitted by Professor Scovell, of the Champaign Illinois Sugar Company, is interesting as bearing upon the importance of favorable climatic conditions. It will be seen that his experience accords with that in Washington. A cool, wet season resulted in the growth of sorghum comparatively poor in sugar.

In order to get a correct idea of the season's work, the condition of the weather as compared with other years, is of material consideration.

In our section of the country, the weather this year, so far as planting, cultivation, maturing of the crop, and the development of the cane sugar in sorghum is concerned, has been the most unfavorable of any year within our knowledge.

I submit, herewith, a synopsis of the weather report, as given by the Signal Service Station at Champaign, showing a comparison of the seasons of this and last year.

MONTHLY MEAN TEMPERATURE.

	1881.	1882.
May	67.4	55.8
June	69.3	69.1
July	76.9	70.1
August	76.7	70.7
Average	72.4	66.4

RAIN-FALL DURING THE SAME PERIOD.

	1881.	1882
May	3.63	8 55
June	4.71	9 93
July	1.07	2 44
August	0 64	4.87
Total	10.05	25.79

From these results, we find the average temperature during the growing season of cane this year, fully 6° F. below that of last year, and the rain-fall exceeded that of last year by fifteen (15) inches.

The season was too wet to cultivate the crop properly, and too cold for the proper development of the sugar in the cane. This last is readily shown by a comparison of the amount of sugar found in the cane this year and last. Last year we found in the Early Amber cane, at its maturity, an average of

	Per cent.
Cane sugar	12.08
Grape "	2.47
And a specific gravity of	1.070

while this year, the same variety under like circumstances, only revealed the presence of

	Per cent.
Cane sugar	8 20
Grape "	3 66
And a gravity of	1.060

We began planting sorghum the 2nd of May, and finished the 22nd of June.

The varieties planted were Early Amber, Early Orange, and Kansas Orange.

The land upon which the sorghum was grown, was rich prairie land, which had been cultivated for upward of twenty years. The preceding crop was broom corn.

As before stated, the extremely wet spring gave the crop a very late start, and the weeds had the advantage. Just as the last difficulty was overcome, the chintz bugs made their appearance, and threatened the destruction of the whole crop. With the exception, however, of lessening the yield somewhat on a thirty-eight acre field, the damage done by them was nominal.

EFFECTS OF FROST UPON SORGHUM.

The investigations concerning this question, practically reconcile the discordant reports in regard to this matter. It has been shown that, when fully matured, the sorghum withstands even hard frosts without detriment—but that, if immature, the effect is most disastrous.

It is shown also, that this disastrous result is due not directly to the effect of the frost, but to the subsequent warm weather, which rapidly induces fermentation with inversion of sugar in the frosted and immature cane.

For the purpose of learning the effect of frost upon the sorghum, the following examinations were made in the fall of 1881, at the Department of Agriculture, at Washington.

An average was taken of all the analyses made of each variety of sorghum under cultivation, just before the dates of the first frosts, which occurred October 6th and 11th, viz.: those analyses which were made September 27th, October 3rd, 4th, 5th, 7th; also, those analyses made immediately subsequent to these frosts, viz: on October 14th, 15th, 17th, 18th. The results are given in the following table:

TABLE SHOWING EFFECT OF FIRST FROSTS.

	Just before October 6th and 11th.					Just after October 6th and 11th.				
	Sucrose.	Glucose.	Solids.	Juice.	Specific gravity.	Sucrose.	Glucose.	Solids.	Juice.	Specific gravity.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
	15.24	.87	2.76	54 28	1.078	14 32	1 16	4 60	57 90	1.078
	13 56	1.39	2.15	51.18	1 073	14 12	1 18	4 14	57 93	1.075
	16 32	1.08	2 74	44 54	1.087	16 59	1 09	5 11	55.81	1.088
	11 85	1 11	3.05	55.10	1 068	16 24	1 27	4 20	55 80	1.082
	12 58	.70	2.40	51.31	1 068	14 65	40	5.03	57 44	1.078
	15 36	.98	2.88	58.06	1.082	13 97	3 28	4 33	52.07	1.084
	14 77	1.31	3.65	59.89	1.082	11 99	1 16	3.73	58.13	1.069
	17.22	.95	2.94	48 46	....	13 88	2 44	3 97	55 23	1 084
	12.54	2.12	2.58	61.19	1.070	13.24	1 85	3 45	58 00	1.076
	17.38	.51	4 12	58 02	1 090	16 30	40	3 80	54 60	1 085
	16 89	.42	3 38	57 25	1.085	16.13	.59	4 87	52 91	1 088
	17.40	.78	......	55.58	1 089	13 90	1 78	4 44	47 38	1 081
	16.57	1 52	3 14	55 84	1.083	14.72	1.64	2 50	58 99	1 079
	18 15	1.39	4 40	55 99	1 094	18 55	1 50	3 59	56 95	1 078
	16.68	1.56	......	49.29	1 089	14 39	1.73	2 93	58 07	1 081
	14.14	2.60	3 67	46.29	1 080	15 25	1 96	2 01	58.51	1.082
	16 10	.94	4 20	53 87	1 085	15 60	1 20	3.47	58.75	1.085
	15.78	1 26	4.01	57 97	1.083	12 41	2 57	1 81	65 80	1.969
	15.77	1.72	4 23	55 99	1 084	12 44	3 02	2 63	60 34	1 075
	15.91	1 27	3.66	51.72	1.082	9 45	1.58	2.31	62 71	1 053
	14.55	2 31	3.11	57 28	1 079	4 64	4.77	2 61	67 31	1 048
	16 22	1.66	4.17	57.98	1.088	10 19	2.46	3 28	56 11	1.067
	11 70	4 14	2.74	63 72	1.071	6 50	3 98	2 97	59 73	1 052
	16.35	1.20	4 15	56 77	1.085	7 27	1.07	3 14	64 03	1.045
	14 86	1 50	3.27	52.94	1 082	12 15	1 92	1 96	60.39	1 071
	13 50	1.43	3.34	......	1.078	11 69	1 28	4.00	59 51	1 066
Av'ge.	15.28	1.41	3.37	54.82	1.0814	12 91	1.82	3.49	58 09	1.0738

AVERAGE RESULTS OF ANALYSES OF THIRTY-SIX VARIETIES OF SORGHUM BEFORE AND AFTER THE FROSTS OF OCTOBER 6TH AND 11TH.

	Before.	After.
Sucrose........per cent	15.28	12 91
Glucose........do......	1.41	1 82
Solids........do......	3.37	3.49
Juice........do......	54 82	58.09
Specific gravity........	1 081	1.074
Available sugar........per cent..	10 50	7 6

From the above averages, it will be seen that the results of these frosts show an average loss of—

	Per cent.
Sucrose	15.5
Specific gravity	8.6
Available sugar	27.6

And a gain of—

	Per cent.
Glucose	29.1
Solids	3 6
Juice	6.0

The above results accord with the general belief as to the injurious effects of frost upon the cane. It would appear from the increase in glucose and decrease in sucrose, that the effects of frost were to produce an inversion of the sugar present in the juices of the plant.

If we consider the average results produced in a few of the different varieties of cane, viz., Mastodon No. 24, Honduras No. 25, Sugar Cane No. 26, Wallis' Hybrid No. 27, White Imphee No. 28, and White Mammoth No. 7, for example, we shall find the effect even more marked. For purpose of comparison, I have given the average results of analyses of the above varieties by themselves, and also the average results of several other varieties by themselves, viz., Early Amber No. 1, Early Golden No. 2, White Liberian Nos. 3 and 4, Black Top No. 5, African No. 6, Regular Sorgho No. 9, Link's Hybrid Nos. 10 and 11.

AVERAGE RESULTS OF ANALYSES OF NOS. 7, 24, 25, 26, 27, 28, MADE JUST BEFORE AND JUST AFTER THE FROSTS OF OCTOBER 6TH AND 11TH.

	Before.	After.
Sucrose ... per cent	14 92	8.34
Glucose ... do	1.98	2.50
Solids ... do	3.58	3 01
Juice ... do	57.89	61.34
Specific gravity	1 081	1 056
Available sugar ... per cent	9.36	2.83

AVERAGE RESULTS OF ANALYSES OF NOS. 1, 2, 3, 4, 5, 6, 9, 10, 11, MADE JUST BEFORE AND JUST AFTER THE FROSTS OF OCTOBER 6TH AND 11TH.

	Before.	After.
Sucrose ... per cent	14 64	15.06
Glucose ... do	1 02	1 25
Solids ... do	2 90	4.39
Juice ... do	54 55	55.83
Specific gravity	1.078	1.082
Available sugar ... per cent	10.72	9 42

The effects of these frosts were far more disastrous upon the first group of sorghums selected, than upon the last group; for, arranging the results side by side, this difference in effect produced is readily compared, thus:

	First Group.	Second Group.
Sucrose........per cent....	Loss........ 44.1	Gain........ 2.9
Glucose........do..	Gain........ 26.3	Gain........ 22.5
Solids ....do........	Loss........ 15.9	Gain........ 51.4
Juice ....do........	Gain........ 6 0	Gain........ 2.3
Specific gravity........	Loss........ 30 9	Gain........ 5.1
Available sugar........ per cent....	Loss........ 69.8	Loss........ 12.1

As will be seen from the above statement, there is practically little effect shown by the frost upon the several varieties of sorghum in the second group. The percentage of increase in glucose and solids is, in fact, not a very large actual increase, while the percentage of sucrose in the juice is slightly more.

It is more than probable that the difference in the effects of the frost upon the two groups is due to the fact, that, in the case of the second group, the different varieties of sorghum were those of early maturity, and this will be seen by reference to the tables of analyses of these varieties, which will show that for a long period these varieties had reached their maximum content of sugar, and, in fact, had begun to fall off a little; while, as will be seen by reference to the tables, the members of the first group were of the late varieties, and their full development had not yet been attained, for their content of sucrose was and had been gradually increasing. It is, therefore, probable that, while the plant is in its immature condition, and the functions of growth and the elaboration of its sugar in vigorous action, it is far more susceptible to the action of frost than after full maturity has been attained. Should this prove to be the case, it would explain the injurious action of frost upon the sugar-cane of Louisiana, which, owing to the long period necessary for its full development, can never reach that condition of maturity which would render it comparatively safe.

The above results will enable us to explain the very conflicting testimony of sorghum growers as to the effects of frost upon their crops, many having experienced no evil results, while others have found the effects of frost most disastrous. At least these results will be of value in guarding us from drawing too hasty conclusions, since a reasonable support is afforded in the above data for either view, and it would seem wise to withhold conclusions until more facts are accumulated.

In 1882, however, as has been already pointed out, the meteorolog-

ical conditions of this locality differed so widely from those of the preceding year, that it effected practically a change of climate. The first frost occurred November 3rd, nearly a month later than upon the two years preceding, and was followed by successive frosts upon November 5th, 6th, 15th, 16th, 19th, 21st, 22nd, 23rd, 24th, 26th, and December 2nd and 4th. The mean temperature after the first frost, and until December 8th, when the last examination of the sorghums was made, was 39.8°, with maximum temperatures, November 12th, of 74.1°, and, November 13th, of 70.8°.

For greater ease of comparison, the above data for 1881 and 1882 are placed side by side in the following table:

	1881.	1882.
First frost	Oct. 6.	Nov. 3.
Other frosts	Oct. 11.	Nov. 5.
	Nov. 14.	Nov. 6.
	Nov. 16.	Nov. 15.
	Nov. 17.	Nov. 16.
	Nov. 28.	Nov. 19.
		Nov. 21.
		Nov. 22.
		Nov. 23.
		Nov. 24.
		Nov. 26.
		Dec. 2.
		Dec. 4.
Mean temperature, October	77.0°	61 0°
Maximum temperature, October	88.6°	81.3°
Mean temperature, November	62.9°	42.9°
Maximum temperature, November	76.1°	74.1°

To show the effects of the frosts this year, there is given in the following table the results of the analyses of the nine varieties which were last examined on December 8th, and, for the purpose of comparison, the last analyses made of these same varieties just before the first frost of November 3rd.

It is important to mention, that each of these nine varieties had ripened their seed some time before the first frost, and that among the nine there were three of the new African varieties, viz: Nos. 7, 12, and 16*a*.

LAST ANALYSES MADE AFTER THIRTEEN FROSTS, DECEMBER 8TH—EFFECTS OF FROSTS, 1882.

VARIETY.	Date.	Per cent of Juice.	Specific Gravity.	Per cent Glucose.	Per cent Sucrose.	Per cent Solids.	Available Sugar.	Polarization.
Neeazana	Dec. 8	42.20	1 0826	3.38	12.88	2 53	6 97	11.48
White Liberian	..do..	35.92	1.0854	3.43	11 78	2 74	5 61	10 94
" "	..do..	34 90	1 0834	3 91	11.92	2 90	5.11	9 83
Link's Hybrid	do..	43.40	1 0905	2.53	14.98	3 00	9 45	13 81
Haswell's Variety	..do..	39.25	1.0953	3 34	15 17	2 61	9 22	13.72
Chinese Imphee	..do.	37.13	1.0932	2 82	14.97	3 09	9 06	.....
Undendebule	..do..	35 01	1 1046	2.33	17.19	3 67	11 19	. .
Dindemuka	..do..	42 54	1 0919	1.96	15 34	3 08	10.30	14 40
Ufatane	.do..	42 16	1 0887	1.95	14.96	3.16	9.85	13.94
Average	......	39.17	1.0906	2 85	14 35	2.98	8.52	12 59

LAST ANALYSES MADE BEFORE FIRST FROST, NOVEMBER 3RD.

VARIETY.	Date.	Per cent of Juice.	Specific Gravity.	Per cent Glucose.	Per cent Sucrose.	Per cent Solids.	Available Sugar.	Polarization.
Neeazana	Nov. 2.	55.45	1.0689	1 54	12.24	3 44	7.26	11 80
		53 96	1.0703	1 79	12 29	2.23	8 27	11.92
White Liberian	Nov. 2.	57 43	1 0731	1.08	13 07	1 93	10.06	12 80
" "	Oct. 25.	53 65	1 0700	1.46	12.37	2.53	8 38	12 11
Link's Hybrid	Oct. 25.	50.83	1 0834	93	15 05	3 20	10 92	15 03
		60 10	1 0777	1.90	11 67	2 39	7 38	11 40
Haswell's Variety	Oct. 30.	58 16	1.0681	1.40	11 61	2.56	7.65	11 11
Chinese Imphee	Oct. 20.	58 27	1 0768	1.42	14.16	...	...	13 60
		58 91	1 0732	·56	13 83	2 49	10.78	13 40
Undendebule	Oct. 30.	60 52	1 0741	.55	13 65	2.86	10 24	13 51
		60.30	1 0693	.44	12.06	3 24	8 38	11.63
Dindemuka	Oct. 30.	60 93	1 0571	.83	9.91	2.64	6 44	9 54
		62 62	1 0669	.94	12.15	2.51	8 70	11 84
Ufatane	Oct. 31.	57 88	1 0692	1 58	11.90	...	...	11 74
		63.86	1 0632	2 01	10.60	2.75	5 84	10 15
Average	....	58.19	1.0707	1.23	12.44	2.68	8 62	12 11

The results above given are very interesting and a little surprising. It will be seen that the average shows, as the effects of these repeated frosts and long continued cold weather of nearly fifty days from the time when the first examinations were made, October 20th, to the last, December 8th, the following:

	Per cent.
Loss of juice	32 69
Gain in specific gravity	28 15
Gain in glucose	131.71
Gain in sucrose	15 35
Gain in solids	11 19
Loss in available sugar	1.16

The average results obtained by the polariscope before the frosts was 97.35 per cent of those obtained by analysis, while the results after the frosts were only 90.84 per cent. This result is, in all probability, due to the presence of inverted sugar in the juice, as is indicated by the increase of glucose, which increase amounts, upon an average, to 1.62 per cent of the juice.

The increased percentage of sugar in these juices, obtained after the frosts, must not be regarded as an actual increase of sugar in the plant; for, on the other hand, there has been a very considerable loss of sugar, as is indicated, not only by the increase in the glucose, which now consists largely of inverted sugar, as the polariscope determinations show, but there has been a very large loss of juice, showing a loss of water. Indeed, there seems in this case to have been a gradual drying up of the water of the plant; and the increased per cent of sugar shows only that the inversion of the sugar and the fermentation and disappearance of the glucose did not proceed quite as rapidly in proportion.

The following table will show the relative composition of the juices before and after these frosts, and the results calculated to the stripped cane:

	Before frosts.	After frosts.
	Per cent.	*Per cent.*
Juice from stalks	58.19	39.17
Sucrose in juice	12.44	14.35
Glucose in juice	1.23	2.85
Solids in juice	2.68	2.98
Total solids in juice	16.35	20.18
Available sugar in juice	8.53	8.52
Water in juice	83.65	79.82
Sucrose expressed from stalks	7.24	5.62
Glucose expressed from stalks	.71	1.11
Solids expressed from stalks	1.56	1.17
Total solids expressed from stalks	9.51	7.90
Available sugar expressed from stalks	4.97	3.34
Water expressed from stalks	48.68	31.27

From the above it will be seen that the effects of these frosts upon the several constituents of the juices, calculated to the stripped stalks, showed

Loss of sucrose	22.38 per cent, or	1.62 per cent of stalks.
Gain of glucose	56.34 per cent, or	.40 per cent of stalks.
Loss of solids	25 00 per cent, or	.39 per cent of stalks.
Loss of total solids	16.93 per cent, or	1.61 per cent of stalks.
Loss of available sugar	32.80 per cent, or	1.63 per cent of stalks.
Loss of water	35.77 per cent, or	17.41 per cent of stalks.

These results above detailed must not be regarded as in conflict with the conclusions published in the annual report 1881–'82, p. 502, where the increase in sugar during the later stages in the development of the sorghum was shown not to be due to a loss of water by drying up of

the plant, as has been supposed by many, but was an actual increase in sugar.

For comparison with the results just given, the results obtained in 1881, are, in part, repeated here.

Two stages of development are selected for comparison—the eleventh, when the seed was just hard, and when the amount of juice was at its maximum; and the seventeeth, which represents several weeks after the seed had ripened.

The average analyses of the juices of 35 varieties of sorghum gave the following results:

	Eleventh. stage.	Seventeenth stage.
	Per cent.	*Per cent.*
Number of analyses	166	197
Juice from stalks	65.04	60.17
Sucrose in juice	10.66	13.72
Glucose in juice	2.35	1.56
Solids in juice	2.72	4.07
Total solids in juice	15.73	19.35
Available sugar in juice	5.59	8.09
Water in juice	84.27	80.65
Sucrose expressed from stalks	6.93	8.26
Glucose expressed from stalks	1.53	.94
Solids expressed from stalks	1.77	2.45
Total solids expressed from stalks	10.23	11.65
Available sugar expressed from stalks	3.63	4.87
Water expressed from stalks	54.81	48.52

Calculating these results to the stripped stalks, we find between the eleventh and seventeenth stages the following:

Gain in sucrose	19.19 per cent, or 1.33 per cent of stalks.
Loss in glucose	38.56 per cent, or .69 per cent of stalks.
Gain in solids	38.42 per cent, or .68 per cent of stalks.
Gain in total solids	13.88 per cent, or 1.42 per cent of stalks.
Gain in available sugar	34.16 per cent, or 1.24 per cent of stalks.
Loss in water	11.48 per cent, or 6.29 per cent of stalks.

It appears, therefore, conclusively established, that long after the seed has throughly ripened, and, indeed, as in all of our results, until the plant is killed by the frost, there is a steady increase in the amount of sugar in the juice, which is actual and not due to loss of water; and that this increase extends also to the available sugar, which, as will be seen above, increased from the eleventh to the seventeenth stages 34.16 per cent, while the sugar increased only 19.19 per cent. This result has been established by the continued experiments of the past four years.

In discussion of the effects of frost upon the sorghums, the following quotation from "Sugar Planting and Refining," page 22, is so entirely in accord with our own experience, that we give it in full:

The sugar-cane attains its greatest perfection within the tropics; cold, in any degree, opposes its growth and development, hence it can not be successfully cultivated in Europe, except in a very prescribed district of Spain. Even in Louisiana, the frost often sets in before the planters can gather the crop, and so affects the cane juice that it can no longer be induced to crystallize, unless the canes can be cut and manufactured before a thaw occurs.

This singular change in the nature of the juice is occasioned by the fluid contents, the saccharine and the nitrogenized principles of the various cells or organs, bursting their bounds and becoming intermingled the one with the other.

While the frost continues, the low temperature prevents the possibility of fermentation taking place, which will altogether prevent the crystallization of the juice if subsequently concentrated.

If the thaw or period of comparatively warm weather has sufficient duration, this viscous fermentation continues until all the sugar contained in the juice is inverted, and the commingled fluids have resolved themselves into a viscid mucilaginous matter, possessing neither sweetness nor acidity. This will occur to the juice of the yet uncut cane; but it also happens to expressed juice under other circumstances. Juice which has become affected in this manner can not be made into crystallizable sugar, and is valuable only for distillation to produce rum. In the upper districts of India, also, frost frequently does great harm to cane crops.

EFFECTS OF FERTILIZERS ON SORGHUM.

The following experiments were made with a view of determining the effect of various fertilizers upon the production of sorghum, in Washington, D. C.

The plat of ground, upon which were grown 37 varieties of sorghum, was 105 by 215 feet in size. The drills were lengthwise the plat, and it was divided into four sections—three of 50 feet and one of 65 feet; and these plats were respectively called A, B, C, D, a corner off A reducing its area to 6,525 feet, the others containing each 5,250 feet. A sample of the soil was carefully selected from many portions of the entire plat, and analyzed, with the following result:

ANALYSIS OF SOIL UPON SORGHUM PLAT BEFORE APPLYING FERTILIZERS.

	Per cent.
Moisture	1.740
Organic matter	4.980
Carbonic acid	.200
Insoluble in acids	84.235
Ferric oxide	2.864
Alumina	4.416
Lime	.635
Magnesia	.400
Phosphoric acid	.198
Potash	.100
Soda	.054
Sulphuric acid	.024
	99.846

An inspection of the analysis of the soil shows it to be exceptional in its very small content of lime, and in the almost entire absence of chlorine. It is, in fact, a gravelly soil, which has been highly cultivated, and very considerably changed in its character. Its need seems chiefly to be the addition of sulphate of lime ("land plaster," or gypsum).

Upon plat A there was applied:

13 pounds of kainite,
5½ " ammonium sulphate,
116 " calcium sulphate.

Upon plat B there was applied:

21 pounds of potassium sulphate,
104 " calcium sulphate.

Upon plat C there was applied:

50 pounds of superphosphate,
104 " calcium sulphate.

Upon plat D there was applied:

50 pounds of bone meal,
104 " calcium sulphate.

The above amounts are equal to an application per acre as follows:

Plat A:

87 pounds kainite,
37 " ammonium sulphate,
774 " calcium sulphate.

Plat B:

175 pounds potassium sulphate,
867 " calcium sulphate.

Plat C:

417 pounds superphosphate,
867 " calcium sulphate.

Plat D:

417 pounds bone meal,
867 " calcium sulphate.

ANALYSIS OF FERTILIZERS USED UPON SORGHUM PLAT.

Superphosphate of lime:

	Per cent.
Soluble phosphoric acid	9.77
Insoluble phosphoric acid	3.63
Reverted phosphoric acid	69
Nitrogen (=NH_3 2.45 per cent)	2.02

Commercial kainite:

	Per cent.
Potassium sulphate	24 74
Sodium sulphate	18 92
Sodium chloride	15.54

Bone meal:

	Per cent.
Phosphoric acid	21.96
Nitrogen (=NH_3 5.22 per cent)	4.30

Sulphate of ammonia:

	Per cent.
Pure ammonium sulphate	98.39
Sulphuric acid (SO_3)	59 63
Ammonia (NH_3)	25.34

Sulphate of potash:

	Per cent.
Pure potassium sulphate	98.79
Potash (K_2O)	53.37
Sulphuric acid (SO_3)	45.42

The superphosphate was such as is commonly sold in this vicinity; it was a good article, but not of the highest grade. The same may be said of the kainite. The other fertilizers were of higher grade. It was thought best to show the effect of each fertilizer on each cane in the various stages of its growth. For this purpose, the results are classified in the three tables to correspond with a content of sucrose; in the first set below 5 per cent, in the second set of 5 to 10 per cent, in the third set of 10 to 15 per cent, and in the fourth set above 15 per cent. It will be understood, that the results embraced in the third and fourth sets are those attained during the period when most of the canes were in the best condition for working; those in the first and second sets are equally valuable as helps in settling the effect of the fertilizers on the immature growing cane; while the final averages must, after all, give the most accurate general idea as to the effect of each fertilizer on each cane during the whole season.

We do not feel warranted in drawing any definite conclusions from these final averages; the close agreement between the averages drawn from so many results, seems to point to the fact that the soil originally contained sufficient food for the proper development of the sorghum plants, and that the addition of these special fertilizers was unnecessary, and resulted in no marked change in the composition of the sorghum juices. In fact, the analyses made the year before showed the canes to have the same composition as they this year were found to have, and equally large crops of four varieties of sorghum were then obtained. These results must not be taken to prove, however, that on certain soils, which are deficient in one or more essential constituents of plant food, the addition of proper fertilizers will not be of great value. Certainly, such additions to poor soils are likely to increase the crop: whether the quality of the juice will be improved, must yet be decided.

Effects of Fertilizers on Sucrose, Glucose, and Solids, in Sorghum Juices.

The three tables which follow represent 634 analyses, made for the purpose of determining what, if any, differences in the composition of sorghum juices are caused by the use of different fertilizing materials.

PERCENTAGE OF

Number of cane.	Variety.	First Set.—Average sucrose below 5 per cent. Fertilizer A.	Fertilizer B.	Fertilizer C.	Fertilizer D.	Second Set.—Average sucrose 5 to 10 per cent. Fertilizer A.	Fertilizer B.	Fertilizer C.	Fertilizer D.
1	Early Amber	....	....	....	....	8 41	....	....	....
2	Early Amber	....	....	....	....	9 17	9.02	11 82	7.84
3	Early Golden	....	....	....	....	8 17	8 42	10.55	9 55
4	Golden Syrup	....	....	....	....	10 62	11.06	7.22	7.44
5	White Liberian	....	....	2 20	....	8.62	7 62	..	....
6	Early Amber	....	....	....	....	....	....	....	....
7	Black Top	...	....	....	...	....	....	....	....
8	African	....	....	....	....	....	....	....	....
9	White Mammoth	....	....	....	....	8.66	9 01	8 47	8 19
10	Oomseeana	....	....	....	....	6.20	9 67	9 50	8.50
11	Regular Sorgho	....	....	..	....	9.15	9 06	10 70	7 67
12	Hybrid	....	....	....	....	....	....	....	....
13	Sugar Cane	....	....	....	....	....	....	....	....
14	Oomseeana	....	....	....	....	....	....	8 23	11.43
15	Neeazana	....	....	....	....	9 08	9 86	8 75	8.66
16	Goose Neck	....	....	....	....	9.38	8 27	8 58	8 84
17	Early Orange	....	....	....	....	8.78	9 63	8 95	8.87
18	Neeazana	....	....	....	....	9.15	9 47	9 35	9.08
19	New Variety	....	....	....	....	....			....
20	Chinese	....	....	....	....	8.33	7.52	8 18	7 67
21	Wolf Tail	....	....	....	....	9.43	9.21	12 58	10 72
22	Gray Top	....	....	....	....	8.29	8 00	7 61	8.33
23	Liberian	....	....	....	....	9 09	8 93	8 34	8 75
24	Liberian	....	....	....	....	8.58	8.52	8 26	8 71
25	Oomseeana	....	....	....	....	9.03	8 74	8.48	8.38
26	Sumac	....	....	....	....	9 73	9.05	8 89	8 52
27	Mastodon	....	....	4.94	4 70	....	....	8 43	8 76
28	Imphee	....	....	....	....	....	....	8 77	8 88
29	New Variety	....	....	....	....	7.42	7.97	8 24	8 07
30	Sumac	....	....	....	....	....	....	8 80	8.54
31	Honduras	1 46	8.73	3 95	4.38	6 68	6.85	7.83	7 82
32	Honey Cane	3.80	3 87	4 05	4 34	8 46	8 08	8 21	6.66
33	Sprangle Top	3 05	3 53	3.59	3.71	6 74	7 39	8.26	8.47
34	Honduras	3 56	4 05	3 40	3 68	8.35	7 99	7 51	7.71
35	Honey Top, or Texas Cane	3 11	3.39	2.89	3 47	6 89	7.17	8 00	7 82
36	Honduras	3 34	3.38	3 29	3 39	7 68	7.72	7.66	7.53
37	Sugar Cane	3.10	6.59	2.27	3.71	8 55	7.41	7 71	8.89
	Averages	3.23	3.98	4.02	3 72	8 17	8.12	8.31	7.65
	Order	C. B. D. A.				C. A. B. D.			

GLUCOSE IN SOLIDS.

THIRD SET.—Average sucrose 10 to 15 per cent.				FOURTH SET.—Average sucrose over 15 per cent.				FINAL AVERAGES.=Average sucrose for each cane.				Number of analyses.
Fertilizer A.	Fertilizer B.	Fertilizer C.	Fertilizer D.	Fertilizer A.	Fertilizer B.	Fertilizer C.	Fertilizer D.	Fertilizer A.	Fertilizer B.	Fertilizer C.	Fertilizer D.	
12.04	12 09	12 34	12.41	.....	.....	.....	.....	11 87	12 09	12 34	12.41	20
11.66	11.54	10.84	12.01	.....	.....	.....	.....	11.28	11 30	10 90	11.78	19
11 54	12 02	11.31	11.03	.....	.....	.....	.....	11 06	11 64	11.18	10.78	19
11.89	12 50	12.36	11.57	.....	.....	.....	.....	19.61	12 34	11.75	11.11	18
13 18	12 70	12 57	13.35	.....	.....	.....	15.20	12.80	12 24	11 62	33 51	11
12 41	12.51	.....	.....	16 31	15.07	.....	.....	12 73	12 73	.....	.....	12
12.71	13.03	.....	.....	15.45	.....	.....	.....	12 91	13.03	.....	.....	13
12 33	12.40	12.10	12.10	.....	.....	.....	.....	12 33	12 40	12.10	12 10	19
13 14	12 60	13 53	13.41	15.30	14.91	15 09	16.15	12 17	11 41	12 68	12 56	13
12 39	12 27	12 59	12 45	.....	.....	.....	.....	10.92	11.58	11 68	11 29	19
12 24	12.23	11 95	12.35	.....	.....	.....	.....	11.95	11 90	11 81	11 86	19
.....	.....	13 67	13 62	.....	.....	15 64	15 48	.....	.....	14 45	14 42	15
.....	.....	13.36	14 08	.....	.....	15 19	.....	.....	.....	13 50	14 08	14
.....	.....	12 25	13 16	.....	.....	15 24	15.43	.....	.....	12.48	13 51	17
12.61	12 84	12 42	12 40	.....	.....	.....	.....	12 28	12.51	19 99	11 98	19
12.41	11 52	11 58	12.33	15 20	.....	15 00	15.13	12 16	10 98	11.22	11 98	19
12 68	12.49	12 82	12 95	15.81	13 78	15 49	15 45	12 42	12 24	12 52	12 62	18
12.72	12.71	13.36	12 39	.....	.....	...		12.38	12.39	12 94	12 06	20
.....	.....	12 05	11 85	.....	.....	15 72	15 29	..		12 97	12 91	13
13.00	12.42	12.49	13 09	.....	.....	.....	.....	11 18	10.40	10 61	10.87	17
.....	.	.....	.....	.....	.....		.	12 13	10 47		.....	13
13 50	11.93	12 75	12.31	15.60	13.87	14.71	15.96	11.14	10.17	10 14	10 52	18
13 19	12.60	13.10	13.59	.....	.....	.....	.....	11.88	11 31	11 34	11.71	20
12.95	12 32	13.40	12.61	.....	.....	.....	.....	11.56	11 05	11 51	11 00	20
13 32	13 01	13 13	13 24	.....	.....	.....	.....	12 04	11.51	11 31	11 62	17
12 52	13 24	13.45	12 61	15.73	13.72	15.84	15.10	11 59	11.03	11.18	10 88	16
.....	.....	11.72	12.96	.....	.....	16 10	16.15	.....	.....	10 10	10 28	17
.....	.....	12.18	13 13	.....	.....	15.64	15 93	.....	.....	11 04	11 54	16
12.51	11 81	13 05	12.17	.....	.....	..	.	10 11	9.89	10 49	9 99	16
.....	.....	11 84	12 54	.....	.....	15.01	16.06	.....	.....	10 63	10 79	15
9.10	10 98	11.36	11 02	.....	.....	.....	.....	7.09	8 17	8 64	8 56	17
12 24	11 69	11 59	11.45	.....	.....	.....	.....	9.23	8 33	8 40	7 87	19
11.00	11.27	11 71	12 18	.....	.....	.....	.....	6.90	7.21	7.55	7 97	21
11 11	12.48	11 69	11.99	.....	.....	.....	.....	7.49	7 87	7 25	7 51	15
11.28	11.11	10 90	12 15	.....	.....	.....	.....	7.04	6 70	6 94	7 62	23
11.79	10 16	12 32	10 87	.....	.....	.....	.....	7.82	7 09	7 49	6 93	19
10.70	9 98	12.15	12.55	.....	.....	.....	.....	8.44	7.89	8 21	8 93	18
12.38	11.38	12.38	12.43	15 60	14.27	15.48	15.50	10.79	10.55	10.82	10.68	
D. A. C. B.				A. D. C. B.				C. A. D. B.				

PERCENTAGES

Number of cane.	Variety.	First Set. — Glucose corresponding with average sucrose below 5 per cent. Fertilizer A.	Fertilizer B.	Fertilizer C.	Fertilizer D.	Second Set. — Glucose corresponding with average sucrose 5 to 10 per cent. Fertilizer A.	Fertilizer B.	Fertilizer C.	Fertilizer D.
1	Early Amber	....	....	....	....	2 19	....	....	....
2	Early Amber	....	....	....	....	1.79	2.58	1.30	1.87
3	Early Golden	....	....	....	....	2.23	1.96	1 83	1 57
[illegible]	Golden Syrup	....	....	....	....	1 65	1 64	2.61	1.80
5	White Liberian	....	....	.67	....	3.18	1.50	....	....
6	Early Amber	....	....	....	....	....	....	....	....
7	Black Top	....	....	....	....	....	....	....	....
8	African	....	....	....	....	....	....	....	....
9	White Mammoth	....	....	.	....	2 45	2.69	3.09	2 89
10	Oomseeana	....	....	....	....	2. 15	2 06	2.17	2.30
11	Regular Sorgho	....	....	....	....	2. 09	2.59	1.54	2.71
12	Hybrid	....	....	....	....	....	....	....	....
13	Sugar Cane	....	....	....	....	....	....	....	....
14	Oomseeana	....	....	....	....	....	....	2.11	1.48
15	Neeazana	....	....	....	....	3.72	3.62	3.75	3.71
16	Goose Neck	....	....	....	....	3.10	3 09	3.02	3.02
17	Early Orange	....	....	....	....	4 03	3 65	3.87	3 73
18	Neeazana	....	....	....	....	3.83	3.49	3.86	3.84
19	New Variety	....	....	....	....	....	....	....	....
20	Chinese	....	....	....	....	3 88	3.49	3.53	3.77
21	Wolf Tail	....	....	....	....	1.18	1 53	....	....
22	Gray Top	....	....	....	....	2 23	2.17	2.28	2.40
23	Liberian	....	....	....	....	3 37	3 51	3 54	3.70
24	Liberian	....	....	....	....	3.65	3.71	3 72	3.88
25	Oomseeana	....	....	....	....	3.82	3.85	3.99	3 99
26	Sumac	....	....	....	....	3.74	3.70	3 98	4 25
27	Mastodon	....	....	4.61	4.82	....	....	2 76	2.42
28	Imphee	....	....	....	....	....	....	4 15	4 03
29	New Variety	....	....	....	....	3.91	3.92	3 73	4 26
30	Sumac	....	....	....	....	....	....	3.98	4.33
31	Honduras	3.06	2 37	2.61	4 61	2.44	2 36	2 21	2 42
32	Honey Cane	4.43	4 46	4 63	4.42	3.19	3 47	3.64	4.12
33	Honduras	4 74	4 93	5 02	5 08	4 15	4.15	3 82	3 56
34	Sprangle Top	4.55	4 59	4 74	4 90	3.67	3.72	3.93	3 57
35	Honey Top or Texas Cane	4 73	4.69	4 80	4.82	4 17	3.94	3 90	3 8
36	Honduras	4 61	5.12	4.86	4 44	3 77	4 06	3 92	3 94
37	Sugar Cane	2.53	1.97	3.09	3 52	2.69	2.27	3.06	3.19
	Averages	4.43	4.50	4.51	4.75	3.22	3.28	3 34	3.40
	Order	D. C. B. A.				D. C. B. A.			

OF GLUCOSE.

Third Set. — Glucose corresponding with average sucrose 10 to 15 per cent.				Fourth Set.—Glucose corresponding with average sucrose over 15 per cent.				Final Averages.—Average glucose for the row.			
Fertilizer A.	Fertilizer B.	Fertilizer C.	Fertilizer D.	Fertilizer A.	Fertilizer B.	Fertilizer C.	Fertilizer D.	Fertilizer A.	Fertilizer B.	Fertilizer C.	Fertilizer D.
1.39	1.52	1 49	1 31	....	....	....	....	1.43	1.52	1.49	1 31
1 54	1 63	1 63	1 38	....	....	....	....	1 58	1.72	1 62	1.44
1 57	1 67	1.66	1 54	....	....	....	....	1.66	1 71	1.69	1 55
1 48	1 52	1 43	1 54	....	....	....	....	1 51	1 54	1.57	1.57
1.44	1.36	1.44	1 34	....	....	....	.98	1.59	1 37	1.37	1.31
1.31	1 56	....	....	1.56	.94	....	....	1.32	1 51	....	....
1 12	1 03	....	....	.46	....	....	....	1.08	1.03	....	....
1 54	1.21	1 45	1 23	....	....	....	....	1 54	1.21	1.45	1.23
1.19	1.25	1.18	1.21	.73	.93	1.00	.88	1.48	1.66	1.54	1.55
1.25	1.55	1 24	1 41	....	....	....	....	1.46	1.68	1 52	1.66
1.27	1.33	1 43	1.49	....	....	....	....	1 34	1 46	1 44	1.62
....	....	1.04	1.10	....	....	.58	.54	....	....	.85	.88
....	....	1.46	1.38	....	....	1 22	1.19	....	....	1.44	1 37
....	....	1.13	1.06	....	....	.66	.76	....	....	1 14	1 04
2.22	2.22	2.41	2.30	....	....	....	....	2.35	2.37	2.55	2.45
1.36	1.83	1 68	1.41	.60	1.07	.85	.69	1.57	1.99	1.87	1.65
1 86	1.97	1.98	2 04	.98	1.08	1.70	1 40	2 03	2.10	2 20	2.20
2.24	2.23	2.21	2 34	....	....	....	....	2 38	2 35	2.37	2 49
....	....	1.37	1.43	....	....	.68	.60	....	....	1.21	1 15
1 66	2.19	2.44	1.89	....	....	....	....	2 51	2 77	2 96	2 72
1 34	1.32	....	....	....	....	....	....	1 31	1.35	....	....
1.27	1.53	1 56	1 74	.95	1.46	1 40	.98	1.67	1.84	1.92	2.03
1.88	2.46	2.10	2.42	....	....	....	....	2 33	2.78	2.58	2 85
2 05	2 61	2 28	2.58	....	....	....	....	2 54	2.94	2.76	3.02
1.79	2.02	1 93	1 98	....	....	....	....	2 40	2 86	2 71	2 69
2.55	2.12	2.15	2.22	1.42	1.64	1 02	1.44	2.93	2.80	2 99	3.28
....	....	1 96	2.01	....	....	.85	1.95	....	....	2.45	2 41
....	....	2 47	2 41	....	....	1.27	1.39	....	....	3 06	2 93
2.45	2.55	2.25	2 34	....	....	....	....	3.14	3.24	3.04	3.36
....	....	2.45	2 32	....	....	1.90	2.42	....	....	3.13	3.26
2.16	2.86	1.64	2 09	....	....	....	....	2.40	2 51	2.07	2.46
1.87	2.69	2 12	2 41	....	....	....	....	2 86	3.43	3 37	3.60
2.39	2 85	2 61	2 05	....	....	....	....	3.83	4.06	3.88	3 64
2 97	2.66	2 97	2 67	....	....	....	....	3 73	3 72	3 94	3 77
2.55	2 88	2.80	2.52	....	....	....	....	3 91	3 99	3.98	3.83
2.32	3.37	2.28	2.55	....	....	....	....	3.55	4.20	3.82	3 88
2.51	2.60	2.42	2.41	....	....	....	....	2.64	2 71	2 91	3.08
1.72	1.87	1 81	1.80	.98	1.25	.88	.94	2 25	2.41	2.38	2.37

B.	B.	B.
C.	A.	C.
D.	D.	D.
A.	C.	A.

PERCENTAGES OF

Number of cane.	Variety.	First Set.—Solids corresponding to average sucrose below 5 per cent.				Second Set.—Solids corresponding to average sucrose 5 to 10 per cent.			
		Fertilizer A.	Fertilizer B.	Fertilizer C.	Fertilizer D.	Fertilizer A.	Fertilizer B.	Fertilizer C.	Fertilizer D.
1	Early Amber	....	....	....	....	3.48	....	....	....
[illegible]	Early Amber	....	....	....	....	3.41	3.44	3.98	4 86
3	Early Golden	....	....	....	....	3.24	2 95	2.36	3.62
4	Golden Syrup	....	....	....	....	3 55	3.06	2.70	2.51
5	White Liberian	....	....	3.12	....	3 19	4 26	....	....
6	Early Amber	....	....	....	....	....	....	....	....
7	Black Top	....	....	....	....	....	....	....	....
8	African	....	....	....	....	....	....	....	....
9	White Mammoth		....	....	....	2 01	2 10	1 83	2 02
10	Oomseeana	....	....	....	....	2 07	2.14	2.74	2.38
11	Regular Sorgho	....	....	....	....	2.44	2.53	2.90	2.38
12	Hybrid	....	....	....	....	....	....	....	....
13	Sugar Cane	....	....	....	....	....	....	....	....
14	Oomseeana	....	....	....	....	....	....	2 50	2 90
15	Neeazana	....	....	....	....	2 49	2.82	2 46	2 80
16	Goose Neck	....	....	....	....	1 97	2 05	2 46	2 70
17	Early Orange	....	....	....	....	1 44	1 73	1 91	2 02
18	Neeazana	....	....	....	....	2 29	3.58	2.50	? 25
19	New Variety	....	....	....	....	....	....	....	....
20	Chinese	....	....	....	....	2 29	2 40	2.57	2 37
21	Wolf Tail	....	....	....	....	2 61	3 53	....	....
22	Gray Top	....	....	....	....	2.58	2 59	2 74	2.36
23	Liberian	....	....	....	....	2 69	2.55	2 28	2 73
24	Liberian	....	....	....	....	2 56	2 47	2 32	2 57
25	Oomseeana	....	....	....	....	2 69	2.74	2 50	2 80
26	Sumac	....	....	....	....	2.42	2.06	2.29	2 55
27	Mastodon	....	....	1.25	1.42	....	....	2 27	2 54
28	Imphee	.	....	....	....	....	....	2 88	3 13
[illegible]	New Variety	....	....	....	....	2 85	2.12	2 31	2 17
30	Sumac	....	....	....	....	....	....	2 58	2.44
31	Honduras	1 11	2 79	2.50	2.04	2 60	2.90	2 59	2 89
32	Honey Cane	1 76	2 01	1.82	1.90	2.15	1 99	1 76	1 76
33	Sprangle Top	1 78	1 72	1.81	1.83	1 84	2 25	1 98	2 12
34	Honduras	1.39	1 72	1.78	1.49	2 16	2.37	1.89	1 79
35	Honey Top or Texas Cane	1 57	1 68	1.63	1 37	1 91	2 07	2.14	2 15
36	Honduras	1 59	1 37	1.66	1.49	1 79	1 91	2 10	1 92
37	Sugar Cane	3.37	3 01	2.29	2.73	2.80	2.53	2 33	2.75
	Averages	1.72	1.81	1.80	1.68	2.39	2.40	2.34	2.46
	Order	B. C. A. D.				D. B. A. C.			

SOLIDS NOT SUGARS.

Third Set.—Solids corresponding to average Sucrose 10 to 15 per cent.				Fourth Set.—Solids corresponding to average sucrose above 15 per cent.				Final Averages.—Average solids for the row.			
Fertilizer A.	Fertilizer B.	Fertilizer C.	Fertilizer D.	Fertilizer A.	Fertilizer B.	Fertilizer C.	Fertilizer D.	Fertilizer A.	Fertilizer B.	Fertilizer C.	Fertilizer D.
3.50	3.28	3.30	3 08	....	....	....	....	3.49	3.28	3.30	3.08
3 44	3 34	3 22	3 46	....	....	....	....	3 44	3 35	3 28	3 54
3 35	3 04	3 26	3 24	....	....	....	....	3 33	3.03	3 15	3.28
3.10	3 16	3.03	3 08	....	....	....	....	3 21	3 15	2 98	3 04
2 87	2 92	2.86	3.16	....	....	....	5.23	2 90	3 04	2 89	3 34
3 15	3.43	....	....	2.54	2.81	....	....	3 10	3 38	....	....
2 83	3.41	....	....	3 75	....	....	....	2 89	3 41	..	.
3 23	3.21	3.19	3 31	....	....	....	....	3 23	3 21	3 19	3 31
3.46	3 14	3 42	4 03	3.16	....	3.02	2.95	3 00	2.67	3 06	3 39
3.02	3 17	3 18	3 60	....	....	....	....	2 78	2 89	3 05	3 24
3.22	2.86	3.19	3 08	....	....	....	....	3 14	2.82	3 16	3.36
....	....	3.43	3 27	....	....	3.90	3 69	.	...	3 62	3 43
....	....	3.22	3 49	....	....	3.88	....	....	....	3 27	3 49
....	....	3 06	3 65	....	....	3·74	4 59	.	....	3 15	3 79
3 02	2.77	3 43	2.96	....	....	....	....	2 97	2 98	3 32	2 94
2.98	2.96	3 06	3 30	4.28	....	4.25	4.73	2 89	2 81	3 02	3 21
2.94	3 11	3 01	3.35	4.47	3.63	3.37	4 43	2.85	2 99	2 90	3.32
3.21	3.03	2 85	3.10	....	....	....	....	3 13	3.09	2 81	3 01
....	....	3 03	3.01	....	....	4 81	5.14	....	....	3 35	3.66
3.66	3.34	3 26	3 28	....	....	....	....	3 13	2 96	2 96	2 90
2 85	3.31	...	....	....	....	....	....	2 83	3 33	..	..
3 65	3 55	3.16	3.36	4 22	....	4.66	4 92	3 17	3 04	3.02	2 95
3 51	3 35	3 60	3 54	....	....	....	....	3.24	3 10	3 11	3 26
3.77	3 49	3 53	3.89	....	....	....	....	3 37	3 13	3 08	3 41
3 31	3.37	3 20	3 37	....	....	....	....	3 11	3 15	2 93	3 18
4.12	4.02	3 33	3 93	3.89	3.84	5 07	4 45	3.24	2 97	2 89	3 30
....	....	2 69	3.40	....	....	4 04	3 97	....	....	2 56	2 83
....	....	3 34	3 12	....	....	5.10	4 22	....	....	3 27	3 19
2 83	2.94	3 21	3.10	....	....	....	....	2 61	2 52	2 73	2 60
....	...	3 89	3 50	....	....	3.40	2 02	....	....	3 25	2 86
2 89	2 96	3 83	3 17	....	....	....	....	2 58	2 91	2 95	2 92
3 25	2 75	2 60	2 84	....	....	....	....	2 51	2 18	2 04	2 15
2 79	2 85	2 92	3 21	....	....	....	....	2 08	2 24	2 12	2 26
2 93	2 96	3 17	3 03	....	....	....	....	2 11	2.31	2.19	2 02
3 23	2 92	2.89	2 97	....	....	....	....	2 15	2 13	2 14	2 25
2.81	2.96	3 50	3 73	....	....	....	....	2 01	1 94	2 21	1 94
2.98	3.77	2 83	4.34	....	....	....	....	2.89	2 86	2.42	2 93
3 22	3.17	3.20	3.30	3.71	3 43	4.04	4 29	2 93	2 86	2 89	3 00
D. A. C. B.				D. C. A. B.				D. A. C. B.			

Effects of Fertilizers on the Ash of Sorghum Juices.

A small number of determinations (34) were made of the ash of various sorghum juices; it was originally intended to make a larger number of estimations for the purpose of showing the effect of these four fertilizers on the amount and composition of the ash in sorghum canes and juices. The pressure of other work and the limited number of assistants prevented the completion of the work, and the results here recorded are given for what they may be worth.

If these results are considered sufficiently numerous to warrant any conclusions, it appears that the amounts of ash are least with fertilizer A, and increase regularly in the order A, B, C, D.

I seems hardly safe, however, to draw any conclusions. We can safely infer, however, that the ash in sorghum juices does not vary greatly from 1 per cent.

The following are the results obtained:

EFFECT OF FERTILIZERS ON THE ASH.

No. of cane.	Fertilizer A.	Fertilizer B.	Fertilizer C.	Fertilizer D.	No. of cane.	Fertilizer A.	Fertilizer B.	Fertilizer C.	Fertilizer D,
1					22		1.46		
2					23				
3	1.13	.95	1.13	1.12	24				
4					25				
5					26		.98		
6					27			.85	.95
7	.90	1.66			28				
8					29				
9					30				
10	1.13	.93	.97	1.11	31				
11		.91			32				
12			1.52	1.55	33				
13			.84	1.00	34				
14			1.23	1.11	35				
15					36				
16	.91	1.03	1.08	1.05	37		.88		
17	.82	.88			10 (Dupl.)	.94	.88		
18		.88				5.83	12.59	8.71	9.01
19			1.09	1.12	No. estimations	6	12	8	8
20		1.15			Average	.97	1.05	1.09	1.13
21									

Effect of Fertilizers upon the Production of Sugar in Sorghum.

Many experiments have been made with a view to the determination of this question. A limited number of these being taken, conclusions apparently well established would follow from such limited examina-

tion. The result, however, of all the experiments, including 34 analyses of the ash of juices from sorghum grown upon plats differently fertilized, leaves the matter wholly undecided.

In the literature of sorghum respecting fertilizers very much may be found, as in that upon sugar-cane and beets, which appears to be well established, at least it is with great confidence asserted; but it is very doubtful whether any conclusion as to the effect of one or another fertilizer upon a sugar producing crop rests upon data involving over 34 analyses of ash—and, as has been said, even this number fails to prove any thing as to the effect of various fertilizers upon sorghum.

The following report upon experiments in the use of fertilizers upon sorghum, in 1881, is made by Prof. George H. Cook, Director of the New Jersey Experiment Station, at New Brunswick, N. J.:

For the study of the effect of fertilizers, sixteen adjoining plats, of one-tenth acre each, were measured off, fertilized as stated in the table, and planted May 23rd, 1881, with Early Amber seed. The cane was doubtless injured by the unusually severe drought: it was noticeable, however, that it suffered much less from this than corn planted on neighboring field. It was harvested on the first of October.

For samples to represent each plat twenty average canes were cut from ten different rows, immediately weighed, and after they had been stripped and topped, again weighed and passed singly between the rollers of a heavy cane mill. The juice from each lot of twenty cane, after it had been carefully mixed, was used for the analysis. The determinations of cane sugar were made by means of the polariscope, using solutions clarified with basic lead acetate and 50 per cent absolute alcohol.

The plan of the experiment was, to ascertain the effect of each of the fertilizing material applied singly and in combination on the production of sugar—to compare the effect of muriate of potash with that of sulphate of potash—and to determine whether by increasing the amount of phosphoric acid used per acre, an advantage would be gained. The action of the fertilizers is best studied in the table under the heading, pounds of extractable sugar per ton of cane and per acre. It was expected that phosphoric acid would materially hasten the maturity of the cane; it appears to have exercised no decided influence in this respect. It caused, however, an increase of 250 pounds, or nearly 30 per cent, of sugar over that yielded by plat No. 15.

Muriate of potash used alone increases the gross weight of stalks very much more than sulphate of potash; it increases too the yield of sugar per acre. It is a fact, however, of especial importance to the manufacturer, that the yield per ton is 20 per cent greater from the plat No. 12, on which the sulphate was used, than from the muriate plat No. 4. Muriates, too, if taken into the sorghum juice, can not be removed by the process of manufacture now used, and interfere seriously with the crystallization of sugar.

As has been well known for many years past, crude barn-yard manure must not be used directly on sugar producing plants. Plat No. 11 draws attention once more to the fact. No noticeable increase in the amount of sugar was caused by it; but a point of much greater importance, is the positive statement of experienced men that sugar will not crystallize from syrup of canes which have been fertilized with it. A heavy dressing on corn land loses its injurious qualities in the course of a year, and sorghum following in rotation is benefited by it.

The expression "extractable sugar" has been used in this table to indicate that a portion only of the total amount of sugar has been extracted by the mill; the bagasse or crushed cane, when it is burned under the boilers or thrown on the compost heap, still contains one-third of the sugur produced by the plant. If the profits of the business are so large that manufacturers can content themselves with two-thirds of the sugar, farmers should endeavor to turn this bagasse into food for sheep, by the process of ensilage. After a struggle which has now lasted more than twenty-five years, sorghum to day does not occupy its true position among sugar producing plants. Its advocates justly claim that this is due to our lack of information, not only in regard to the mauufacture of sugar from it, but also in respect to its proper cultivation.

	No manure.	350 pounds superphosphate.	150 pounds nitrate of soda.*	150 pounds potassium chloride.	350 pounds superphosphate, 150 pounds sodium nitrate.	No manure.	350 pounds superphosphate, 150 pounds potassium chloride.	150 pounds sodium nitrate, 150 pounds potassium chloride.
Cost of fertilizers per acre	$0 00	$6 10	$7 50	$3 40	$13 60	$0 00	$9 50	$11 .00
Pounds of sorghum per acre...	11,515	13,365	14,820	16,000	14,440	11,170	11,640	12,390
Pounds of stripped and topped cane per acre...	8,406	9,890	11,263	12,160	10,830	8,378	8,846	9,293
Per cent of juice extracted from stripped and topped cane.....	69 6	67.0	66.4	68.0	66.8	64.2	65.1	64.3
Pounds of juice extracted per acre.	5,851	6,626	7,479	8,269	7,234	5,379	5,759	5,975
Per cent of sugar in juice......	9 70	9.43	9.00	9.27	9.68	9.94	10.51	11 68
Pounds of extractable sugar per acre......	568	625	673	767	700	535	605	696
Pounds of sugar extracted per ton of cane..	135	126	120	126	129	128	137	150
Pounds of clean seed per acre..	1,020	1,351	1,298	1,246	1,344	1,132	1,038	1,067

* 16 per cent phosphoric acid.

	350 pounds superphosphate, 150 pounds potassium chloride, 150 pounds sodium nitrate.	400 pounds calcium sulphate.	20 two-horse loads barn-yard manure.	200 pounds potassium sulphate.	350 pounds superphosphate, 200 pounds potassium sulphate.	200 pounds potassium sulphate, 150 pounds sodium nitrate.	200 pounds potassium sulphate, 150 pounds sodium nitrate, 350 pounds superphosphate.	200 pounds potassium sulphate, 150 pounds sodium nitrate, 700 pounds superphosphate.
Cost of fertilizers per acre.. ...	$17 10	$1 60	$10 00	$6 50	$12 60	$14 00	$20 10	$26 20
Pounds of sorghum per acre .	12,590	12,680	12,375	11,605	11,650	12,505	13,260	14,036
Pounds of stripped and topped cane per acre	9,946	9,510	9,405	8,820	8,854	9,504	9,812	10,943
Per cent of juice extracted from stripped and topped cane. .	67.3	64.8	64.4	68 2	69.0	68 3	68 9	67.8
Pounds of juice extracted per acre...	6,694	6,162	6,057	6,015	6,109	6,491	6,760	7,413
Per cent of sugar in juice.	11.43	9.84	9 57	11 61	9.73	9.73	9.44	12.01
Pounds of extractable sugar per acre	765	606	580	698	594	632	638	891
Pounds of sugar extracted per ton of cane	154	128	122	158	134	133	130	168
Pounds of clean seed per acre..	1,305	1,136	1,160	1,216	1,226	1,139	1,349	1,278

Professor Magnus Swenson, of the University of Wisconsin, at Madison, gives the following as the result of his experiments with fertilizers in 1882.

One plot of one and a quarter acres, was used for experiments with fertilizers. Each kind of fertilizer was put on a plot of cane of one-twentieth of an acre, and these plots were separated from each other by guard rows, where no fertilizer was used. Each lot was cut and brought to the mill separately, and a sample from the defecated juice was taken for analysis.

The following table gives the results:

Fertilizers.*	Nitrogen on plat.	Cane sugar.	Glucose.	Stripped stalks.
	Pounds.	*Per cent.*	*Per cent.*	*Pounds.*
No. 1. No manure	....	10 91	2.80	828
No. 2. 2239 pounds barn-yard manure..........	....	10.19	2.77	864
No. 3. Nitrogen mixture	1.2	10.57	2.77	796
No. 4. Superphosphate (15 pounds)..	... .	10.54	2 80	762
No. 5. Chloride of potassium (7½ pounds)	....	10.95	2.78	910
No. 6. Nitrate of sodium (7½ pounds); Superphosphate (15 pounds)	1.2	10 77	2.56	776
No. 7. Nitrate of sodium (7½ pounds); Chloride of potassium (15 pounds) ..	1.2	10 17	2 78	856
No. 8. Superphosphate (15 pounds); Chloride of potassium (7½ pounds) ..	.. ..	10 83	2.89	778
No. 9. Barn-yard manure	....	10.87	2 85	578
No. 10. No manure	....	11 63	2 85	616
No. 11. Mixed minerals and nitrogen	1.2	11 34	2.76	472
No. 12. Mixed minerals and two-thirds nitrogen.	.8	10 92	2 80	578
No. 13. Mixed minerals and one-third nitrogen.	.4	10.41	2.94	548
No. 14. Mixed minerals and one-sixth nitrogen..	.2	10 10	2 86	560
No. 15. Mixed minerals and one-twelfth nitrogen	.1	11 59	2 90	618
No. 16. Mixed minerals and no nitrogen.........	....	10.47	2 87	590

* The "nitrogen mixture" consisted of sodium nitrate, ammonium sulphate, and dried blood in equal parts.

The "superphosphate" contained about 16 per cent of phosphoric acid.

The "chloride of potassium" contained about 50 per cent of potash.

The "mixed minerals" was composed of two-thirds of superphosphate, and one-third chloride of potassium.

The amount applied to one-twentieth of an acre, besides the nitrogen mixture in the experiments Nos. 11 to 15 inclusive, was the same amount used in experiment No. 8, viz.: Superphosphate 15 pounds, and chloride of potassium 7½ pounds.

The yield of stripped stalks upon the two plats with no manure, Nos. 1 and 10, differs as widely as any of the others, one being 828 and the other 616 pounds, while the sucrose and glucose in the two are practically alike in quantity. Also Nos. 3 and 11 give 795 and 472 pounds of stripped stalks respectively, though both received the same amount of nitrogen. This result by itself, would make it appear that the "mixed minerals" upon plat 11 had been injurious; but, in No. 8, the yield was about the same as in No. 3.

Again, in contrasting Nos. 9 and 10, we have an apparent falling off in weight of stalks (a surprising result), while the content of sugar is practically unchanged. It will be seen that Professor Cook obtained, by the use of barn yard manure, 9,405 pounds of stripped stalks, while the average of his two no manure plats gave only 8,392 pounds, and the percentage of sugar in the juice was practically the same in both, viz.: 9.57 per cent with barn-yard manure, and 9.82 per cent without manure.

As to the effects of barn-yard manure, Professors Weber and Scovell, of Illinois Industrial University, report as follows:

To ascertain the effect of manure, a field was selected which had been used as a barn-yard for several years. A part of the cane was planted directly on the rotten manure pile. An analysis was made of a sample taken from this part of the field, as well as of a part away from the manure pile. The seed in each case was in the "hardening dough." The following is the result of the analysis:

Manured—Sp. gr. 1 063. Grape sugar 2.65. Cane sugar 10.89.
Unmanured—Sp. gr. 1.074. Grape sugar 2.65. Cane sugar 13.37.

The lower specific gravity of the juice from the plat so highly manured, is what might be expected from a rank growth under such circumstances, and the longer time necessary to its complete maturity. It would have been interesting to have had the analysis of this cane a month later, to have seen whether it would not have shown an increase in specific gravity and sugar content.

At least the experience as recorded, is not against the use of barnyard manure, as a fertilizer for sorghum.

It appears from these results, that, although this question of the fertilizers is one of great practical importance, the data attained by experiments thus far, is by no means sufficient to enable one to draw reliable conclusions.

It is especially important that we guard against the tendency to hasty conclusions, which is the greater if our limited data apparently confirms our preconceived notions.

COMPOSITION OF SOIL AS AFFECTING SORGHUM.

The character and composition of the soils best adapted to the cultivation of sorghum for sugar production, as also the proper method of fertilization necessary for the best results, are obviously matters of fundamental importance.

At present our knowledge is very limited, and the number of carefully ascertained facts so small, as hardly to warrant more than conjecture.

In many respects, the habits of the sorghums, and their demands upon climate and soil, are almost identical with those of the several varieties of maize; and yet there appear to be, in certain respects, marked differences. It is known that, when fairly established, the sorghums, as a class, are capable of sustaining a period of drought which would prove fatal to maize; and not only this, but that such drought and the accompanying high temperature, results in the development of an unusual amount of sugar in the plant.—(See Annual Report Department of Agriculture, 1881–82, page 456.)

It will be seen, by consulting the results of our experiments as to the effects of fertilizers upon the sugar content and ash in the juices of the several sorghums (see page 172) that, although a very large number of determinations were made, the average result of all was such as to leave the matter wholly unsettled.

To those who may desire to aid in these and similar investigations, a careful study of these results above referred to, may be helpful as showing the extreme danger of hasty generalizations; for any half dozen of the analytical results, selected at random and considered alone, would, in most cases, warrant a conclusion, more or less decided, which the increase of testimony renders less and less probable.

The results of the past year, 1882, at Rio Grande, N. J. (where they produced 320,000 pounds of sugar, and where, upon fields identical in character there was great variation in the amount of crop produced),

were such as to awaken great interest in these questions of soils and fertilization. Besides, the juices of the sorghums there grown proved to be remarkably pure, comparing well even with the best sugar-cane juice. Therefore, average specimens of the soils from the several fields were obtained, and a record of the yield of crop, and the fertilizers applied to each, was also secured from the president of the Sorghum Sugar Company, George C. Potts, Esq., of Philadelphia, Pa.

Rio Grande is a small hamlet some 6 miles north of Cape May, N. J., in latitude 39° north, and longitude nearly 2° east from Washington. It is situated upon a sandy peninsula, about 5 miles in breath, with the Atlantic upon the east, and separated from the main-land by the Delaware Bay, at this point about 20 miles wide. Average samples of soil from six fields were selected for analysis, viz:

A. *Harne farm.*—This field received an application of 300 pounds of Peruvian guano per acre. The average yield of stalks was 3½ tons per acre

B. *Richwine farm.*—This farm also had 300 pounds Peruvian guano per acre. The average yield was 5½ tons of stalks per acre.

C. *Hand farm.*—This field received an application of 300 pounds of Peruvian guano and 30 bushels of lime per acre. The average yield was 7½ tons of stalks per acre.

D. *Neafie farm.*—This field received same amount of guano and lime as C. Average yield per acre, 8 tons stalks.

E. *Uriah Creese farm.*—Same amount of guano and lime as C and D. Average yield per acre, 15 tons stalks.

F. *Bennett farm.*—Same amount of guano and lime as C, D, and E. Average yield per acre, 17 tons stalks.

From the above results, it will be seen that the application of the expensive fertilizer, Peruvian guano, was without any apparent benefit, while the application of lime seems to have been beneficial, although it is to be regretted that we have not the data for comparing the yield of these fields with and without the application of fertilizers.

With the exception, only, that the amount of pebbles of an appreciable size, one-twentieth to one-quarter inch in diameter, was more in some of the samples than in others, there was to the eye no noticeable difference in the character of the soil.

The samples were passed through sieves of 20, 30, 40, 50, 60, 70, 80, 90 meshes to the inch, and the following results obtained: The column marked residue, consisted of pebbles which would not pass through a sieve of twenty meshes to the inch, or rather of one-twentieth inch diameter. The column marked 20 was that portion which, passing meshes of one-twentieth inch, would not pass those of one-thirtieth, etc.

Besides these six samples of soil from Rio Grande, N. J., analyses have been made of several other soils, upon which sorghum was grown the past year, as follows:

G. *Grounds of the Department of Agriculture.*—The recent treatment of this plat, is given in the annual reports of the past three years. The sample for analysis was taken November, 1882.

H. *Soil No.* 1.—*Great Bend, Kas.*—This soil has been cultivated for six years. The yield was 10½ tons stalks per acre. No fertilizer used.

I. *Soil No.* 2.—*Great Bend, Kas.*—This soil was plowed for the first time. The yield per acre was 8 tons of stalks. No fertilizers were used.

J. *Soil from Rising City, Nebr.*, upon which 18 tons per acre of sugar beets were grown, which gave, on analysis, an average of 12.27 per cent of sugar in the juice.

K. *Soil from Hutchinson, Kas.*–Yield of sorghum, 6 tons stalks per acre.

L. *Soil from Sterling, Kas.*—Under cultivation for three years in cereal crops. A black, sandy loam. Average yield per acre, 7 tons stalks.

M. *Soil from Sterling, Kas.*—A black, sandy loam. Under cultivation for seven years with crops of cereals. Crop very promising, but destroyed by hail.

N. *Soil from Sterling, Kas.*—Black, sandy loam. Under cultivation for five years in cereal crops. Average yield per acre, 12 tons of stalks.

O. *Soil from Sterling, Kas.*—A strictly sandy soil, in cereals for five years. Average yield per acre, 10 tons of stalks

PER CENT OF SOILS PASSED THROUGH SIEVES.

	Residue.	20.	30.	40.	50.	60.	70.	80.	90.	Total.
A	27.8	4 2	5.9	3.6	2.5	3 0	4 3	3.9	44 8	100
B	22 7	5 1	8.9	7.8	5.0	6.0	11 2	6.4	26 9	100
C	3.0	6.7	17 6	16.5	8 8	8.8	11.4	10 6	16 6	100
D	5.7	7.2	16.7	13 6	9.6	8 2	9.8	12 0	17.2	100
E	8.2	6 2	12.2	8.7	7 5	6 9	9 8	8 3	32 2	100
F	5 5	6.9	18.6	12.5	8 7	9 4	9 7	8.0	20.7	100
G	5.5	1.6	6.6	7.2	3 9	3 6	5.1	7.9	58 6	100
H	2.2	1.1	2.9	3.3	3 7	2 6	7 3	6.8	70.1	100
I	.3	.3	.9	1.0	1 2	.7	2 2	4.5	88 9	100
J	.2	.5	1	1	.1	.6	.1 1	1.5	95 8	100
K	.7	.3	.8	1 0	.7	.9	2.1	2 0	91.6	100
L	1 8	3.0	7 4	5.6	5 1	3 1	4 6	4 6	64.8	100
M	4.9	1.4	3.3	3 2	2.1	2 7	4.2	3 3	74 9	100
N	1 0	.9	3.3	7.5	6 5	4 2	9 6	12 9	54 1	100
O	.9	1.6	9.2	8 6	11 3	9.3	14 6	14.7	29.8	100

The mechanical condition of a soil determines often its degree of fertility, quite as much as chemical composition. This state of extreme comminution is said to account for the great fertility of the tchernozème or black soil of Southern Russia, which, upon chemical

analysis, does not appear any better than ordinary soils, and yet its productiveness is such that, as has been said of it:

> The Russian proverb, "One can not distinguish the generous from the rich," may be most appropriately applied to the tchernozème. It appears rich because it is generous.

It is commonly known, that the mineral matter, which composes the larger part of every good soil, has been derived originally from rocks which, during comparatively recent periods, geologically speaking, have been disintegrated by one agency or another, and that those supplies of mineral food necessary to the plant, in any soil, must have previously existed in the rocks from which this soil was produced.

But those agencies, as frost, water, attrition, the carbonic acid and oxygen of the air, which have in the past reduced these rock masses to every degree of fineness, from small pebbles to impalpable powder, are still operative; and gradually, year by year, day by day, new supplies of mineral food are being unlocked from these rock fragments and made available to the plant. Besides, it will be seen, that, as this pulverization goes on, the surface exposed to the action of these agencies, above mentioned, increases in geometric ratio, and so, in consequence, the disintegration becomes proportionately the more rapid.

To illustrate: Suppose a block of granite 1 foot square to be broken into cubes of 6 inches square, there would be obviously 8 cubes produced, and the surface exposed in the first case, being 6 square feet, would be doubled. Let this process be repeated, and the surface becomes 24 feet square. Continue this operation for only 25 times, and our block of granite 1 foot square, with 6 square feet of surface, becomes resolved into minute fragments of quartz, feldspar, and mica, about one three-millionth of an inch in diameter, and presenting an aggregate surface of over 7 square miles; and yet there is no reason to suppose that the comminution ceases at such limits; indeed, there is every reason to believe that the plant is incapable of assimilating food which is not absolutely in the molecular condition.

The calculations of Sir William Thompson show the size of the molecule to be, at his largest estimate, only one hundredth the diameter, or one millionth the bulk, of the fragments to which we have reduced our block of granite in the above illustration.

The importance, then, of assisting these agencies by good tillage is obvious; indeed, an agriculturist, of long experience and distinguished success, has declared that he would prefer to have an ordinary field well plowed without manure, than poorly plowed with it.

So far as the partial mechanical analysis goes, it quite fails to throw any light upon the cause of the very wide difference in the crops grown upon the Rio Grande soils.

For example, the soils, C, D, F, are very much alike, and yet their respective yields per acre in tons of stalks were 7½, 8, and 17. It is obvious that much of this might have been due to difference in cultivation, but it does not appear that there was practically any difference in this respect.

Chemical Composition of the Soils.

The following table shows the results of the chemical analysis of the several soils. The absence of other than mere traces of chlorine in the Rio Grande soils is remarkable, in view of the fact that these fields were lying within a few hundred yards of the ocean. It is possible that the heavy fall rains had leached such compounds below the surface, from which alone the samples were taken for analysis. It was intended to make still further examination of the subsoils of these several fields; for it may be that sorghum, being, through its root system, a deep feeder, will account for good crops of cane upon land which failed to grow good crops of other kinds:

	A	B.	C.	D.	E.	F.	G.
Water	.830	.680	190	350	.430	180	1.140
Organic	4 730	3 500	1 290	2 180	2 420	1.780	4 690
Insoluble	87.008	92 243	96 910	93 837	93 167	95.297	84 670
Fe^2O^3	2 555	1 775	.940	1 110	1 500	1.445	3 440
Al^2O^3	4 110	1 640	.550	1.765	1 805	1 060	4 360
CaO	.315	305	225	.375	.460	.505	.860
MgO	.390	.290	.147	185	180	.190	.367
K^2O	.238	.124	.061	.085	.122	.074	394
Na^2O	Trace.	.023	Trace.	... ..	012	Trace.	.023
P^2O^5	088	047	024	.034	.043	.026	.265
SO^3	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.
Cl.	.044	.009	003	004	.005	.003	009
CO^2	....	... ...	..	.130	.. ...	Trace.	Trace.
	100.308	100.636	100 340	100 055	100 144	100 560	100 228
Nitrogen	.128	067	045	.045	.078	062	.146

	H.	I.	J.	K.	L.	M.	N.	O.
Water	1 000	300	1 140	.330	400	.470	.300	.360
Organic	4 320	5.820	7 320	4 830	4.310	5.150	2.520	1 330
Insoluble	85.250	84 625	78 162	86 282	87 792	81 882	91 544	94 231
Fe^2O^3	3 605	3.330	4 550	3 270	2 775	3 270	2 330	1.775
Al^2O^3	3 575	3 890	5 805	3.385	3 005	3 665	1 835	1.465
CaO	.710	.760	.715	.565	.660	2 685	450	.505
MgO	325	.450	820	.595	380	690	.390	230
K^2O	524	538	686	437	.482	397	.301	257
Na^2O	.... .	... .	Trace.	059	Trace.	042	.050	Trace.
P^2O^5	047	.046	042	.026	010	017	.024	.017
SO^3	Trace.	.115	Trace.	.050	Trace.	044	.036	.041
Cl	.004	.019	017	.007	.027	.019	.019	.017
CO^2	....	....	... .	....	...	1 695	....	......
	99 360	99 893	99 257	99 836	99 941	99 976	99 799	100 228
Nitrogen	151	190	.230	.162	.140	.146	.034	.050

For purpose of comparison, analyses are given of two sugar-cane soils, from a pamphlet on the agricultual chemistry of the sugar-cane, by Dr. T. L. Phipson.

A is soil from Jamaica, under cane for the first time.

B is soil from Demerara, which has been steadily under cane for 15 years.

C is soil from the Philippines, which grows a superior quantity and quality of sugar-cane—analysis by R. H. Harland.

	A.	B.	C.
	Per cent.	*Per cent.*	*Per cent.*
Moisture	12 25	18 72	6 79
Organic matter and combined water	15.36	6 03	25.05
Silica and insoluble	48 45	68 89	53 39
Alumina	13.80	2.50	13 16
Oxide of iron	6 72	2 60	4.80
Lime	.99	.08	1.60
Magnesia	.29	.25	.42
Potash	.11	.10	1.14†
Soda	.70	.09	
Phosphoric acid	.10	.03	.25
Sulphuric acid	.30	.03	.09
Chlorine	.51*	Trace.	....
Oxide manganese, carbonic acid, and loss in analysis	.42	.68	.10
	100 00	100 00	100.00
Nitrogen in organic matter	.31	.05	....

Dr. Phipson calls attention to the greater amount of organic matter, nitrogen, lime, and phosphoric acid in A, and to the important fact, that the quantity of lime (.08) in B is far below that of the magnesia (.25). This he regards as a very bad sign in cane soil. He deduces from the results of a numerous series of analyses made by him, that the degree of exhaustion which a cane soil has suffered may be determined by comparing the relative amounts of lime and magnesia present in them.

In support of this view, he gives analyses of four samples of cane soils from Guiana, A and B having been cultivated from ten to fifteen years, and C and D having been cultivated over sixty years:

	A.	B.	C.	D.
Lime............ Per cent.	.44	.64	.11	.40
Magnesia........ " "	.32	.50	.36	.51

* This quantity of chlorine is unusually high, and is accounted for by the proximity of a salt spring.

† The potash, soda, chlorides, together.

In view of the above facts, it is not improbable that a similar explanation will suffice for the remarkable results obtained at Rio Grande, N. J.

In the following table, the crop of stalks produced, with the per cents of lime and magnesia in the several soils, is given, for purpose of comparison with ratio of lime to magnesia.

	Tons stalks.	Per cent lime.	Per cent magnesia.	Ratio lime to magnesia.	
A	3½	.315	.390	100	124
B	5½	.305	.290	100	95
C	7	.225	.147	100	65
D	8	.375	.185	100	49
E	15	.460	.180	100	39
F	17	.505	.190	100	38

It will be remembered, that, while each of the above soils had received an application of 300 pounds of Peruvian guano per acre, the soils C, D, E, and F, had, in addition, received 30 bushels of lime per acre. It is also very interesting to observe that, as the relative amount of the magnesia compared with lime in the above soils fell off the crop of cane increased.

For purposes of comparison, the tons of stalks produced per acre, with the per cents of the lime and magnesia, and their ratio, is given for the other soils analyzed:

	Tons stalks.	Lime.	Magnesia.	Ratio lime to magnesia.	
G	15	.860	.367	100	43
H	10½	.710	.325	100	46
O	10	.505	.230	100	46
L	7	.660	.380	100	58
I	8	.760	.450	100	59
N	12	.450	.390	100	87
K	6	.565	.595	100	105

In the above list, the order of arrangement is according to the ratio of lime to magnesia, and it will be seen that the crop from soil N is the only one which is fairly exceptional to the conclusions laid down by Dr. Phipson in his examination of sugar-cane soils. The ratios of L and I are almost identical, and there is but a ton difference in the yield per acre; also, the actual amount of lime present in I is greater than that in L.

At the several conventions of sorghum growers, the discussion of the soil best suited to the growth of sorghum has been general; but the

result shows that, at present, our knowledge is too limited to enable us to speak with any positive assurance. It has been urged, that new land was better than old, on account of the greater ease of cultivation, and greater freedom from weeds; but in the main, at present, the quality of soil best adapted to the cultivation of sorghum, is far more a matter of opinion than established by fact.

A general opinion prevails, that a sandy upland soil, well drained, and not freshly manured, is the best.

Professors Weber and Scovell, of the Illinois Industrial University, in the report of their experiments with sorghum, give the following results:

Effects of Soils.—The following analyses were made to study the effect of different varieties of soil upon the production of sugar in sorghum. But, as other circumstances (as, locality from which seed was obtained, time of planting, and manner of cultivation) may affect the amount of sugar, many more investigations would have to be made before definite conclusions could be reached. The table, however, shows that sorghum can be grown successfully on all varieties of soil specified:

TABLE SHOWING THE EFFECTS OF DIFFERENT SOILS ON THE DEVELOPMENT OF SUGAR IN SORGHUM.

VARIETY OF SOIL.	Number.	Years in cultivation.	Fertilization.	Variety of cane.	Specific gravity of juice.	Grape sugar.	Cane sugar.	Average.
Prairie	1	27	Manured 3 years ago	Amber..	1 068	2 47	12.48	Grape, 2.94 Cane, 11.28
	2	7	No manure.	Amber..	1.074	3 65	10 10	
	3	27	Manured 4 years ago	Amber..	1 070	3.26	12 52	
	4	Unknown ..	No manure...	Amber..	1 070	2 71	10.77	
	5	Very old...	No manure...	Amber..	1.070	2 61	10.51	
Virgin prairie	6	....	No manure..	Amber..	1 070	3 92	11.89	Grape, 3.46 Cane, 12.77
	7	....	No manure...	Amber..	1 072	3 00	13.65	
Timber land...	8	Unknown ..	Barn-yard manure..	Amber..	1 074	2.65	13.37	Grape, 3.07 Cane, 12.87
	[illegible]	10	Manured 4 years ago	Amber..	1.067	3.46	12.49	
	10	12	No manure...	Amber..	1 074	3.10	13 18	
	11	4	No manure...	Amber..	1 076	2.97	13 64	
	12	4	No manure...	Amber..	1,070	2 98	12 80	
	13	Many.......	No manure...	Amber..	1.066	3.16	11.76	
Miss'ippi sand land...	14	....	....	Amber..	1.063	2.61	13.47	Grape, 2.39 Cane, 12.30
	15	....	....	Amber..	1 056	2.18	11.14	

CHAPTER VII.

DEVELOPMENT OF SUCROSE AND GLUCOSE IN SORGHUM.

For the purpose of determining the condition of the sorghum plant, in the several stages of its existence, there were planted upon the grounds of the Department of Agriculture, at Washington, in the spring of 1879, four varieties of sorghum, viz., Early Amber, White Liberian, Liberian, and Honduras.

On the 18th of July, when the plants had attained such development that their panicles or seed heads were just beginning to appear at the top, one or two stalks were selected of each variety, the juice expressed and analysed; and this examination was continued, at intervals of a few days, during the entire season, and after severe frosts. The detailed results of these analyses will be found on page 189. The following chart graphically represents the results of the analyses. The line which represents the "Average sucrose in sugar-cane," is the average per cent found in triplicate analyses of the three principal varieties of sugar-cane grown in Louisiana. These canes were analyzed by the same methods used in the analyses of the sorghum juices.

The line representing the average per cent of sucrose in sugar beets, is from the results of analyses of thirteen specimens of sugar beets grown upon the Agricultural College farm, Amherst, Mass., and analyzed by Professor Goessmann (*vide* Massachusetts Agricultural Report, 1870–'71).

It will be observed how closely the Early Amber and the Liberian correspond in their development, being almost identical, and yet being clearly distinct varieties. While these two varieties attain a content of sugar in their juices equal to the average in juice of the sugar-cane by the middle of August, the Liberian does not reach this condition until the last of September, and the Honduras not until the middle of October.

After having attained approximately the maximum content of sugar, this condition is maintained for a long period, affording ample time to work up the crop.

It is doubtless true, that had the season been longer, it would have been found that the Liberian and Honduras, having once attained this full devolopment of sugar, would also have retained it; but, as is seen by the chart, the heavy frosts and subsequent warm weather which happened about October 24th, caused a rapid diminution of sucrose in each variety, and a corresponding increase in glucose.

The converse of what is found true of the sucrose is clearly shown as to the development of the glucose, and it is seen that a minimum quantity once attained is continued a long time, and that this minimum is quite as low as the average amount found present in the sugar-canes.

It was most unfortunate, as tending to retard the development of the sorghum sugar industry, that Dr. C. A. Goessmann, through his examination of canes, which, through long keeping after being cut up had suffered an inversion of their sugar, should have concluded his report, made in 1879, on the Early Amber cane, in these words: "The presence of a large amount of grape sugar *in all the later stages* of the Early Amber, as well as of all other varieties of this species, is a serious feature in the composition of the juice, impairing greatly the chances for a copious separation of the cane sugar by simple modes of treatment." This sweeping conclusion is quite at variance with the results which have just been recorded, and does not appear to be justified by the facts upon which it is based, as will be seen upon page 129.

It is obvious that the results depicted upon the chart are not to be taken as entirely exact, but the general fact represented is, without doubt, true, and with a still larger number of observations, the approach to true curves would be found nearer than here represented.

An average of all the examinations made of these four sorghums, during these periods when they were suitable for cutting, gives the following results:

Early Amber, from August 13th to October 29th inclusive, 15 analyses, extending over 78 days, 14.6 per cent sucrose.

White Liberian, from August 13th to October 29th inclusive, 13 analyses, extending over 78 days, 13.8 per cent sucrose.

Liberian, from September 13th to October 29th inclusive, 7 analyses, extending over 46 days, 13.8 per cent sucrose.

Honduras, from October 14th to October 29th inclusive, 3 analyses, extending over 16 days, 14.6 per cent sucrose.

It will be seen, that, in the four varieties grown, it was most fortunate to have had those differing so widely from each other in nearly every respect, except only the all-important one, their practical equality in their content of sugar after they had reached maturity.

When each variety had quite matured, the greater portion of each was taken, and samples of excellent sugar was made without trouble, and in considerable quantity, from each.

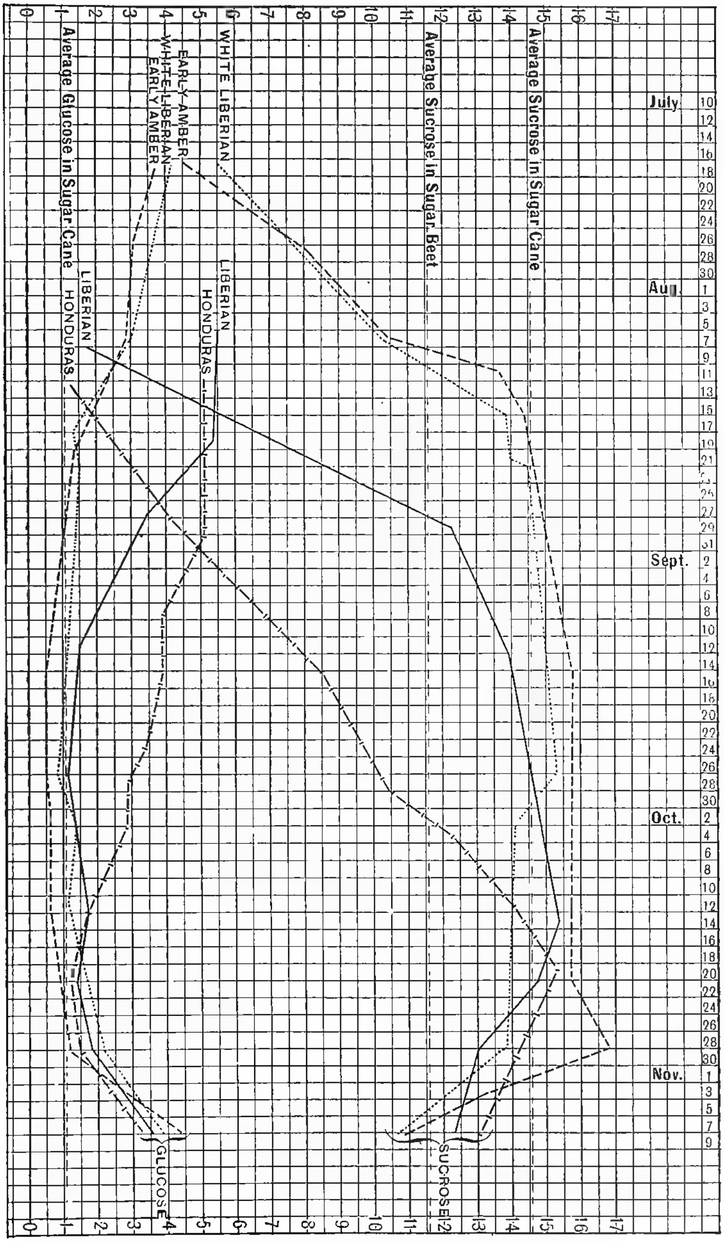

Average Glucose in Sugar Cane
Average Sucrose in Sugar Beet
Average Sucrose in Sugar Cane
WHITE LIBERIAN
EARLY AMBER
WHITE LIBERIAN
EARLY AMBER
LIBERIAN
HONDURAS
LIBERIAN
HONDURAS
GLUCOSE
SUCROSE
July
Aug.
Sept.
Oct.
Nov.

Plate XVII.

After the encouraging results of 1879, which have just been recorded, the examination of many other varieties of sorghum and maize was continued at the Department of Agriculture in 1880; 1881, and 1882, including, in all, the examination of about 100 varieties of sorghum and 20 varieties of maize, for the purpose of determining the nature of certain changes going on during the life of the plant, and especially to determine that period when, in each variety, the content of sugar was at its maximum, as, also, to learn the length of time during which this practical maximum was retained.

To this end, the examinations were, in some instances, begun so soon as a stem had fairly formed in the plant, in order to determine how early in its life the presence of sugar could be detected; and, in all cases, the examinations were begun long before even the panicle had appeared, and before any one would think to work the crop for either sugar or syrup. These examinations were continued almost daily with each variety, till long after frosts, and the results of each variety were tabulated, and may be found in the Annual Reports of the Department of Agriculture for those years.

The interest and value which these results have, in giving, as they do, in a condensed form, the life history of these plants, is such that the detailed examinations of three varieties is here given.

The following tables show the results of the analyses of three varieties of sorghum stalks, made during the season of 1881, at Washington, D. C.—the date of each analysis, the dimensions and weight of the stalk, the percentage of juice obtained from the stalk and the specific gravity of the juice, the per cent of sucrose, glucose, and of the solids not sucrose nor glucose present in the juice. In addition, there is given the percentage of sucrose present, as determined by the polariscope, which will be found to correspond closely with the percentages of sucrose as determined by analysis.

An examination of these tables of analyses reveals the following facts: In the earlier stages in the growth of each plant, the amount of crystallizable sugar (sucrose) is small; but, as the plant matures, the sucrose rapidly increases until it equals from 12 to 16 per cent of the juice. The "solids not sugar" in the juice also increase from the first, but very much less rapidly than does the crystallizable sugar; at the same time, the uncrystallizable sugar (glucose) steadily diminishes, so that the purity of the juice (shown in the column marked "available sugar") increases constantly until the cane is ready to be worked.

These facts, and the inferences to be drawn from them, will be more fully discussed in connection with the general averages deduced from these figures. See page 189.

EARLY AMBER.

Date.	Development.	Number of stalks.	Length.	Diameter at butt.	Total weight.	Stripped weight.	Juice expressed.	Specific gravity of juice.	Glucose in juice.	Sucrose in juice.	Solids not sugar.	Available sugar.	Polarization.
	Stage.		Feet.	Inch.	Lb.	Lb.	Pr. ct.		Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.
June 27....	....	9	2.0	.8	.	.	55.80	1.014	1.25	.07	1.91	—3.09	.....
July 5 .	....	6	2.8	.6	3.5	2.7	56.44	1.017	2.21	.70	.....	.....	.....
July 16 ...	1	1	5.	.6	.8	.6	53.69	1.028	3.15	1.15	2.65	—4.65	.....
July 16 ...	2	1	5.5	.6	.8	.6	62.29	1.026	2.92	1.52	1.45	—2.85	.....
July 11....	3	2	5.	.7	1.4	1.1	70.85	1.021	2.20	.58	4.10	—5.72	.....
July 14 ..	4	1	5.5	.8	.9	.7	63.50	1.025	2.96	1.32	....	.....	.....
July 15....	4	1	7.5	.9	1.3	.9	66.26	1.023	2.60	30	3.50	—5.80	.....
July 15....	5	1	8.5	1.1	1.9	1.1	63.80	1.023	2.61	.99	2.80	—4.42	...
July 20 ...	6	1	7.5	.7	1.1	9	68.23	1.047	3.17	3.10	2.42	—2.49	.....
July 23....	7	1	8	.6	96	8	65.79	1.041	3.54	4.83	3.63	—2.34	....
July 23...	8	1	7.7	.6	1.02	8	65.81	1.036	3.57	3.53	3.27	—3.31	...
July 25 .	[illegible]	1	7.4	.7	1.1	9	62.68	1.040	2.68	7.33	2.47	. 2.18	7.02
July 25 ...	9	1	6.5	.8	1.0	.8	69.48	1.047	2.75	7.12	2.54	1.83	7.25
July 28 ...	9	2	7.5	.7	1.8	1.4	67.23	1.053	2.87	8.41	1.87	3.67	7.96
July 29 ...	10	2	7.2	.6	2.0	1.8	60.00	1.058	3.02	9.02	2.75	3.25	9.18
July 29	10	.		......	...	....	...	1.057	2.82	9.49	2.87	3.80	9.21
Aug. 1 ...	11	2	8.	.6	1.7	1.5	64.66	1.066	2.47	12.25	2.87	6.91	11.39
Aug. 8 ..	12	1	7.8	.6	1.1	.9	63.37	1.072	1.86	12.96	5.04	6.06	12.82
Aug. 13 .	13	1	8.0	.6	1.0	8	64.51	1.071	1.57	14.27	3.30	9.40	13.89
Aug. 18....	14	1	7.8	.7	1.3	1.0	63.59	1.083	1.55	14.83	3.93	9.35	.....
Aug. 24 ...	15	2	8.0	.6	1.9	1.4	56.10	1.083	.98	16.47	2.91	12.58	.....
Aug. 26 ...	15	1	7.4	.7	1.4	9	63.25	1.080	.76	15.43	3.06	11.61	.....
Aug. 27....	15	1	9.4	.7	1.4	1.0	56.01	1.091	1.11	16.13	?7.42	...	.....
Aug. 31...	16	2	8.5	.6	1.7	1.3	52.77	1.091	1.09	18.43	3.27	14.07	....
Sept. 3 ..	17	1	7.5	.7	1.4	1.0	52.88	1.091	.80	18.61	?6.81	....	......
Sept. 7 ..	17	2	8.5	.8	2.9	2.1	54.17	1.089	.80	18.23	3.00	14.43	?16.92
Sept. 10 .	18	2	9.5	.5	2.1	1.6	49.91	1.089	1.26	17.55	4.15	12.14	.....
Sept. 17 ...	18	1	9.2	.6	1.1	.8	43.83	1.088	.86	17.09	3.64	12.59	....
Oct. 5....	After 18	1	9.0	.7	1.3	.8	54.28	1.078	.87	15.24	2.76	11.61	.....
Oct. 15 ...	...do...	2	8.0	.7	1.7	1.3	57.90	1.078	1.16	14.32	4.60	8.56	13.96
Oct. 22....	...do....	1	7.3	.5	1.1	.7	56.13	1.076	1.27	14.23	3.50	9.96	17.01
Oct. 27 ...	...do ...	1	7.5	.8	1.1	.8	56.90	1.083	92	15.76	4.18	9.66	.....
Oct. 29 ..	...do ...	2	8.0	5	2.2	1.5	57.82	1.077	.89	12.65	5.77	5.99	14.76
Nov. 2...	...do....	2	8.3	.5	1.9	1.3	61.98	1.074	1.23	13.91	3.24	8.44	...
Nov. 4 ...	...do....	2	7.3	.6	1.3	1.1	59.96	1.069	1.02	12.59	3.41	8.16	12.76
Nov. 7....	...do....	2	8.4	.8	1.7	1.2	50.00	1.076	.83	14.01	3.51	9.67	14.03
Nov. 9....	...do...	1	9.0	.6	1.1	.9	54.52	1.074	.89	13.82	3.72	9.30	13.97
Nov. 12 ...	...do....	1	8.0	.8	1.0	.8	48.85	1.077	.82	14.00	3.84	9.34	13.86
Nov. 15 ...	...do....	1	7.2	.6	1.0	.7	55.42	1.073	.95	14.27	2.20	11.12	14.09
Nov. 17....	...do ...	1	5.7	.8	1.1	.8	53.96	1.075	1.46	13.03	4.25	7.12	....

LINK'S HYBRID.

Date.	Development.	Number of stalks.	Length.	Diameter at butt.	Total weight.	Stripped weight.	Juice expressed.	Specific gravity of juice.	Glucose in juice.	Sucrose in juice.	Solids not sugar.	Available sugar.	Polarization.
	Stage.		*Feet.*	*Inch.*	*Lb.*	*Lb.*	*Pr. ct.*		*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*
July 8	....	1	5.	.7	1.5	1.1	70.69	1.017	1.47	.93	3.10	-3.64	.....
July 18	1	1	6.5	1.1	1.6	1.2	72.45	1.025	2.19	2.22	2.51	-2.48	....
July 19	2	1	7.	.9	1.5	1.2	66.00	1.030	2.13	3.04	1.18	-.27	.....
July 20	3	1	7.7	.8	1.7	1.3	68.52	1.033	2.39	4.34	3.14	-1.19	.....
July 27	4	1	9.0	.9	1.8	1.4	65.19	1.047	2.39	7.46	1.86	3.21	7.17
July 28	5	1	9.7	.8	1.7	1.4	67.64	1.049	2.72	7.21	2.22	2.27	6.58
July 29	5	....	....	....	....	....	...	1.047	2.84	7.05	.71	3.50	6.50
July 30	6	1	9.7	.9	2.0	1.6	61.69	1.052	2.48	7.90	2.54	2.88	7.96
Aug. 2	6	2	9.8	.8	3.5	2.8	65.29	1.062	2.15	10.66	3.06	5.45	.....
Aug. 5	7	1	9.1	1.0	1.2	.9	63.72	1.052	2.61	8.01	3.87	1.53	7.69
Aug. 10	8	1	9.7	.9	1.7	1.3	67.50	1.064	2.70	11.25	1.55	7.00	10.65
Aug. 15	9	1	11.1	.9	1.7	1.3	63.39	1.069	1.98	12.22	2.54	7.70	12.12
Aug. 19	10	....	....	....	....	....	..	1.071	2.06	12.79	2.42	8.31	12.19
Aug. 19	10	1	11.2	1.0	2.0	1.7	64.07	1.071	2.03	12.46	2.78	7.65	....
Aug. 25	11	1	11.0	.9	1.8	1.5	64.04	1.082	1.69	15.73	2.54	11.50	15.14
Aug. 25	11	....	....	....	....	....	..	1.082	1.69	15.87	2.64	11.54	15.31
Aug. 29	12	1	11.1	.9	1.7	1.4	65.11	1.082	1.38	15.58	3.51	10.69	.....
Sept. 1	13	1	10.5	.9	1.6	1.3	63.20	1.082	1.58	16.41	2.43	12.40	.....
Sept. 5	14	1	11.2	.9	1.7	1.5	62.81	1.089	1.21	18.05	3.28	13.56	17.10
Sept. 5	14	....	.....	.....	.....	.....	..	1.088	1.55	17.20	3.67	11.98	.....
Sept. 8	15	1	11.1	.9	1.5	1.3	54.59	1.094	.66	18.86	3.33	14.87	.....
Sept. 12	16	1	11.0	1.0	1.8	1.5	59.56	1.086	1.03	17.03	2.56	13.44	....
Sept. 19	17	1	11.2	.8	1.8	1.4	55.21	1.091	.34	18.28	?7.09	?10.85	.....
Oct. 7	After 18	1	11.3	1.1	2.1	1.7	57.25	1.085	.42	16.89	3.38	13.09	.....
Oct. 17	....do....	1	10.5	1.0	1.9	1.5	52.91	1.088	.59	16.13	4.87	10.67	....
Oct. 25	....do ...	1	9.9	1.0	1.8	1.3	58.56	1.080	.42	15.32	3.32	11.58	14.75
Oct. 28	....do ..	1	11.5	.9	1.9	1.4	56.83	1.085	.49	16.22	4.81	10.92	...
Oct. 31	....do....	1	11.0	1.0	1.6	1.2	54.78	1.074	.44	13.77	5.43	7.90	13.69
Nov. 2	...do....	1	9.0	.8	1.5	1.1	59.75	1.079	.37	14.92	4.91	9.64	15.22
Nov. 4	....do ...	1	11.2	.7	1.5	1.2	54.32	1.085	.29	15.89	4.55	11.05	.
Nov. 7	....do....	1	11.0	.9	1.8	1.4	58.93	1.074	.39	13.11	5.12	7.60	
Nov. 10	....do....	1	11.2	1.0	1.6	1.3	55.76	1.082	.21	15.36	4.30	10.85	15.17
Nov. 12	....do....	1	10.4	.9	1.5	1.1	58.18	1.073	.47	12.15	5.27	6.41	.....
Nov. 15	....do....	1	11.0	1.0	1.6	1.5	61.68	1.079	.37	15.14	3.35	11.40	15.38
Nov. 17	....do	1	10.9	1.0	1.4	1.0	59.74	1.082	.43	13.68	4.96	8.29	15.46

NEW VARIETY.—F W. STUMP.

Date.	Development.	Number of stalks.	Length.	Diameter at butt.	Total weight.	Stripped weight.	Juice expressed.	Specific gravity of juice.	Glucose in juice.	Sucrose in juice.	Solids not sugar.	Available sugar.	Polarization.
	Stage.		*Feet.*	*Inch.*	*Lb.*	*Lb.*	*Pr ct*		*Pr ct*	*Pr ct*	*Pr ct*	*Pr ct.*	*Pr ct.*
July 6.	1	2	5 5	.8	2 4	1 9	68 48	1 020	3 12	.74	2 21	—4 59	....
July 18.	2	1	6.0	.6	7	6	70 26	1.025	3 64	.39	4 31	—7.56	.....
July 11.	3	1	6 5	.9	1 4	1 1	72 40	1.023	3 11	.74	2 74	—5.11	.....
July 12.	3	1	6 5	.7	1 2	1 0	72.67	1 023	3 06	1 37	3 39	—5.08	.....
July 13.	4	1	6.7	1.0	1.2	1.0	73.03	1 025	3 29	1.00	3 31	—5 60	.....
July 13.	5	1	7 0	.9	1.3	1 1	70 95	1 026	3 33	.41	4 73	—7 65	....
July 15.	6	1	8 5	.8	1 3	1 1	64 20	1.026	4 32	.81	2 37	—5 88	.....
July 19.	7	1	8 3	.6	1.1	.9	68 51	1 042	3 63	4 92	.....	?+1.29	....
July 20.	8	1	8 4	.8	1 6	1.3	69 86	1 045	3 33	6 00	2 44	+ .23	.....
July 20.	9	1	8 4	.6	1.2	.9	69 30	1.042	3.54	5.28	3 03	—1.29	......
July 21.	9	1	9.0	.6	1.2	1.0	70 02	1.042	3 36	8 54	... .	?+5 18	....
July 23.	10	1	8 7	.7	1.3	1.1	69 81	1.048	3 11	7 23	4.38	— 26	... .
July 26.	10	1	8 6	.7	1.4	1.2	71 59	1.050	3 27	7 39	2 19	+1 93	6 80
July 27.	10	1	8 7	.7	1.6	1 3	72.68	1.050	3 29	7 52	2 57	1 66	7 46
July 28.	10	1	8 5	.8	1.3	1 1	69 69	1.058	2 95	9 38	2 79	3 64	9.39
July 29.	10	1	8.2	.7	1.0	.8	71.55	1 056	4 20	7 58	2 32	1 06	.....
Aug. 5.	11	1	8.8	.7	1.4	1.2	65 42	1.073	1.61	14.54	3 37	9 56	.....
Aug. 10.	12	1	8.1	.8	1.5	1 3	67 07	1.070	2 47	13.06	1.76	8 83	13 20
Aug. 10.	12	1	9 0	.8	1.6	1.4	67 60	1.073	2 23	13 76	1 76	9 77	12 38
Aug. 15.	13	1	8 2	.7	2 0	1.2	61 19	1 082	1.01	17 19	1 62	14.56	16 41
Aug. 20.	14	1	8.6	.8	1 5	1.1	58 41	1.083	1.15	16.40	3.96	11.29	16 53
Aug. 25.	15	1	7 7	.7	1 2	1.0	61.11	1 086	1 65	17 25	2.28	13 37	
Aug. 30.	16	1	9.0	.8	1.2	1 0	60 25	1 088	1 14	17 46	3 36	12.96	17 58
Sept. 1.	16	1	9 0	.8	1 6	1 2	58 60	1 087	1.09	18 13	2.85	14.19	.....
Sept. 5.	17	1	9.0	.8	1.5	1 2	60 72	1 091	1 51	18.48	2 64	14.33	...
Sept. 8.	17	1	9 2	.8	1.4	1 2	63 87	1 098	1 26	18 81	2 97	14.58	18 70
Sept. 14.	18	1	9.0	.9	1.3	1.1	59.00	1.091	1.14	18.61	3.16	14.31	.. ..
Sept. 19.	18	1	8 1	.7	1.2	.9	55.58	1 089	.78	17 40	?5 92	?10 70	.....
Oct. 11.	After 18	1	8.0	.8	1.4	.9	59.39	1.086	1.15	17.18	2.71	13 32	.. ..
Oct. 17.	....do....	1	9.5	.8	1.3	.9	47.38	1.081	1.78	13.90	4.44	7 68	.....
Oct. 25.	....do....	1	9.0	.9	1.1	.8	53.72	1.071	2.50	11.11	5 01	3 60	9.73
Oct. 28.	....do....	1	8.6	.7	1.3	1.0	56.68	1.084	.88	15.77	4 56	10.33	15.37
Oct. 31.	....do....	1	8.0	.7	1.3	.9	61.22	1.067	1.85	12.04	3 63	6 56	11.76
Nov. 3.	....do....	1	8.7	.8	1.7	1.2	57.93	1.074	.81	14.70	2.78	11.11	13 64
Nov. 5.	....do...	1	8.5	.8	1.1	1.0	54.48	1.068	1.42	12 25	2.90	7 93	11.49
Nov. 8.	....do....	1	10.0	.6	1.3	1.1	53.24	1.058	1.82	9 33	4 25	3 26	....
Nov. 11.	....do....	1	9.4	.9	1.6	1.2	57.29	1.080	1.04	14.29	3 79	9 46	13 95
Nov. 14.	....do....	1	8 2	.7	1.0	.8	55.00	1 071	1.52	12 19	3 42	7 25	12 04
Nov. 16.	....do....	1	9 0	.7	1.0	.8	56.43	1.073	1.53	12.74	3 76	7 45	12.32
Nov. 18.	....do....	1	9.5	.8	1.0	.7	51.70	1.065	1.98	9.76	4.59	3.19	8.97

Analyses of Three Varieties in Different Stages.

The following tables, from the Annual Report, Department of Agriculture, 1881–'82, represent the average results of the analyses of three varieties in the several stages of development, each table containing only the analyses of a single stage, and the general average of all the analyses of all varieties at each separate stage is given. An examination will show that there is practical agreement in all these sorghums, the only difference being in the time from planting necessary for the different varieties to attain to any given stage.

EARLY AMBER.

Stage.	Average date of estimation.	Observed date of reaching stage.	Number of determinations.	Glucose.	Sucrose.	Solids not sugar.	Total solids.	Per cent of sucrose by polarization.	Available sucrose.	Average juice.	Average specific gravity.
				Pr ct	*Pr ct*	*Pr ct.*	*Pr ct*		*Pr ct.*	*Pr ct*	
-1	July 1	July 1	2	1.73	.39	1.91	4 03	......	......	56 12	1.016
1	July 16	July 9	1	3.15	1.15	2.65	6.95	....	.....	53.69	1.028
2	July 16	July 11	1	2 92	1.52	1.45	5.89	....	......	63 29	1.026
3	July 11	July 13	1	2.20	.58	4 10	6.88	....	....	70.85	1.021
4	July 14	July 15	2	2.78	.81	3.50	5 27	....	......	64.38	1.012
5	July 15	July 18	1	2.61	.99	2.80	6.40	....	...	63 80	1.023
6	July 20	July 19	1	3.17	3.10	2 42	8.69	......	....	68.23	1.047
7	July 23	July 20	1	3.54	4.83	3 63	12 00	....	....	65.79	1.041
8	July 23	July 25	1	3.57	3 53	3.27	10 37	......	....	65.81	1.036
9	July 26	July 27	3	2.73	7 62	2 29	12 64	7 41	2.60	66.46	1.047
10	July 29	July 30	2	2 91	9.26	2 81	14 98	9.19	3.54	60 00	1.057
11	Aug. 1	Aug. 3	1	2.47	12 25	2 87	17 59	11 39	6 91	64.66	1.066
12	Aug. 8	Aug. 9	1	1 86	12.96	5 04	19 86	12.82	6.06	63 37	1.072
13	Aug. 13	Aug. 12	1	1 57	14.27	3 30	19 14	13.89	9.40	64 51	1.071
14	Aug. 18	Aug. 16	1	1.55	14.83	3 93	20 31	....	9.35	63.39	1 083
15	Aug. 26	Aug. 19	3	.95	16 03	2 97	21 44	....	12 11	58 45	1.085
16	Aug. 31	Aug. 26	1	1.09	18 43	3 27	22.79	....	14.07	52.77	1 091
17	Sept. 5	Sept. 3	2	.80	18 42	3 00	22 22	16.92	14 62	53 53	1.090
18	Sept. 13	Sept. 10	2	1 06	17 32	3 94	22 32	.... ..	12 32	46.87	1 089
After 18	Oct. 10	... ...	2	1.01	14.78	3 68	19 47	13.96	10 09	56 09	1 078
After 18	Oct. 20	....	1	1 27	14 23	3 50	19 00	17 01	9 46	56.13	1.076
After 18	Oct. 30	....	4	1.01	13.75	4 15	18 91	13.76	8.49	59.16	1 076
After 18	Nov. 10	......	3	.85	13 94	3 69	18.48	13 95	9.40	51.12	1.075
After 18	Nov. 17	....	2	1.20	13.65	3.22	18.07	14.09	9.23	54.69	1.074

LINK'S HYBRID.

Before 1	July 8	July 8	1	1.47	.93	3.10	5.50	....	.....	70.69	1.017
1	July 18	July 16	1	2.19	2 22	2 51	6 92	....	.....	72 45	1.025
2	July 19	July 20	1	2.13	3.04	1.18	6 35	......	....	66.00	1.030
3	July 20	July 25	1	2.39	4.34	3 14	9 87	.... ..	—1.19	68.52	1 033
4	July 27	July 27	1	2.72	7.46	1.86	12 01	7.17	2.84	65 19	1.047
5	July 28	July 29	2	2 66	7.47	1.62	11 75	6.59	3.18	67.64	1 048
6	Aug. 1	July 30	2	2.31	9 28	2.80	15.39	7.96	4.17	63.49	1 057
7	Aug. 5	Aug. 2	1	2.61	8.01	3.87	14.49	7.69	1.53	63.72	1 052
8	Aug. 10	Aug. 4	1	2.70	11.25	1.55	15 50	10.65	7.00	67.50	1.064
9	Aug. 15	Aug. 6	1	1.98	12.22	2.54	16.74	12 12	7.70	63.39	1.069
10	Aug. 19	Aug. 12	2	2.05	12 63	2.60	17 28	12.19	7 98	64 07	1 071
11	Aug. 25	Aug. 17	2	1.69	15 80	2.59	20 08	15.23	11.52	64.04	1 082
12	Aug. 29	Aug. 19	1	1.38	15 58	3 51	20 47	....	10.69	65.11	1 082
13	Sept. 1	Aug. 25	1	1.58	16 41	2.43	20.42	....	12.40	63.20	1 082
14	Sept. 5	Sept. 1	2	1 38	17.63	3.48	22 49	17.10	12.77	62.81	1.088
15	Sept. 8	Sept. 8	1	.66	18.86	3.33	22.85	....	14.87	54.59	1.094
16	Sept. 12	Sept. 12	1	1 03	17 03	2.56	20.62	... .	13.44	59.56	1.086
17	Sept. 19	Sept. 19	1	.34	18.28	? 7.09	? 25.71	....	10.85	55.21	1.091
After 18	Oct. 10	....	1	.42	16.89	3.38	20.69	....	13.00	57.25	1 085
After 18	Oct. 20	....	2	.50	15 73	4.09	20.32	14 75	11.14	55.73	1.084
After 18	Oct. 30	..... .	4	.45	15 20	4.92	20 57	14.45	9.83	56.42	1.081
After 18	Nov. 10	....	3	.36	13.54	4.89	18.79	.....	8.29	57 62	1.076
After 18	Nov. 17	....	2	.40	15.41	4.15	19.96	15.39	10.86	60.71	1.080

NEW VARIETY.—F. W. STUMP.

Stage.	Average date of estimation.	Observed date of reaching stage.	Number of determinations.	Glucose.	Sucrose.	Solids not sugar.	Total solids.	Per cent of sucrose by polarization.	Available sucrose.	Average juice.	Average specific gravity.
				Pr ct	*Pr ct.*	*Pr ct*	*Pr ct.*		*Pr ct.*	*Pr ct.*	
1.	July 6	July 6	1	3 12	.74	2.21	6 02	....	.....	68.48	1.020
2.	July 18	July 7	1	3 64	.39	4.31	8 34	....	.....	70.26	1 025
3.	July 11	July 9	2	3.08	1.05	3.06	7.19	....	......	72 58	1.023
4.	July 13	July 11	1	3.29	1.00	3.31	7.60	....	......	73.03	1.025
5.	July 13	July 13	1	3 33	.41	4.73	8.47	....	......	70 95	1.026
6.	July 15	July 15	1	4.32	.81	2.37	7.50	....	......	64.20	1.026
7.	July 19	July 18	1	3.63	4.92	....	8 20	....	....	68.51	1.042
8.	July 20	July 19	1	3.33	6.00	2.44	11.77	....	.23	69.86	1.045
9.	July 20	July 20	2	3 45	6.91	3.03	13 39	....	.43	69.66	1.042
10.	July 26	July 27	5	3.36	7.82	2 85	14.03	7.88	1.61	71.06	1.052
11.	Aug. 5	July 30	1	1.61	14.54	3 37	19 52	....	9.56	65.42	1.073
12.	Aug. 10	Aug. 8	2	2.35	13 42	1.76	17.53	12.79	9.31	67.34	1.072
13.	Aug. 15	Aug. 13	1	1 01	17.19	1 62	19.82	16 41	14.56	61.19	1.082
14.	Aug. 20	Aug. 19	1	1.15	16.40	3 96	21.51	16.53	11.29	58.41	1.083
15.	Aug. 25	Aug. 25	1	1.65	17.25	2.28	21.18	.....	13 32	61.11	1.086
16.	Aug. 30	Aug. 30	2	1.12	17.80	3 11	22.03	17.58	13.57	59.43	1.087
17.	Sept. 6	Sept. 1	2	1.39	18 65	2 81	22.85	18.70	14 45	62.30	1.095
18.	Sept. 17	Sept. 14	2	.96	18.00	3 16	22 12	....	13.88	57.29	1.090
After 18	Oct. 10	....	1	1.15	17.18	2 71	21.04	.....	13 32	59 39	1.086
After 18	Oct. 20	....	2	2.14	12.50	4.73	19.37	[illegible] 73	5.63	50 55	1.076
After 18	Oct. 30	....	4	1 24	13.69	3 47	18 40	13 06	8.98	57.58	1.073
After 18	Nov. 10	....	3	1.46	11.94	3.82	17.22	12.99	6 66	55.18	1 070
After 18	Nov. 17	....	2	1.75	11.25	4.17	17.17	10.65	5.33	54.09	1.069

General Averages for each Stage in 1880.

The following table, deduced from the results of 2,739 analyses of sorghum canes, made at Department of Agriculture, Washington, presents, in a condensed form, a very correct idea as to the actual development of the cane itself, and of the changes in the juice.

Among the points of most practical interest may be mentioned the following:

1st. The changes in height, weight, diameter, and total and stripped weight, are not sufficiently important to require comment.

2nd. The percentage of juice extracted from the stripped stalks gradually increases up to the eleventh stage, then slowly diminishes until the close of the season.

3d. The specific gravity of the juice, the percentage of sucrose, the percentage of solids not sugar, and the available sugar, regularly increase (with but one or two exceptions) until the close of the season; and the percentage of glucose in the juice as steadily decreases from the first.

It will here be noticed, that the sucrose increases in the juice much more rapidly than do the solids not sugar; and this fact, taken together

with the steady decrease of glucose, is the explanation of the equally steady increase of the available sugar, which represents the comparative purity of the juices.

4th. It is stated in the discussion of the table of specific gravities, that the proper stage in the development of sorghum at which to begin the manufacture of sugar, is when the juice has the specific gravity 1.066, corresponding with 6.6 per cent of available sugar.

Confirmation of this statement is here furnished by this table, and we further see that this specific gravity (1,066) is attained when the cane reaches what has been named the "13th stage."

By reference to the table describing these stages, it appears that the seed of the plant should be quite fully developed and hard.

By these three indications, every cane grower can judge for himself as to the proper time to work up his sorghum crop, in order that he may obtain satisfactory results.

At the same time, an analysis of the juice is always valuable, and should be made when practicable.

GENERAL AVERAGE FOR THE STAGES, AS DETERMINED FROM THE RESULTS OF THE SAME STAGE FOR ALL VARIETIES OF SORGHUM, IN 1880, AS DETERMINED AT DEPARTMENT OF AGRICULTURE.

Stages.	Average length.	Diameter.	Unstripped weight.	Stripped weight.	Per cent of juice.	Specific gravity.	Per cent glucose.	Per cent sucrose.	Per cent solids.	Per cent available sucrose.	Number of juices analyzed.
1	7 5	0 9	1 93	1.34	59.06	1.031	4.29	1.76	1.75	—4.28	58
2	8 5	0.9	1.93	1.46	59.60	1 036	4 45	2.96	1 86	—3.35	69
3	8 8	.9	1.78	1.39	59 67	1.037	4 50	3.51	1 78	—2.74	57
4	9 1	.8	1.83	1.44	61.61	1.041	4.34	4.34	1 91	—1 91	70
5	9 3	.9	1.96	1.55	63 05	1 045	4.15	5.13	1 92	— .94	75
6	9 7	.9	2 02	1.60	62 79	1 050	3.99	6 50	2.45	+ .06	62
7	9 7	.9	2.11	1.55	63.85	1.052	3.86	7.38	2.19	1.33	70
8	9 3	1.0	2 10	1.63	65 68	1 055	3.83	7 69	2.37	1 49	111
9	8.8	.9	1.87	1.40	64.88	1 058	3.19	8.95	2 42	3.34	266
10	8 9	.9	1.81	1.38	64.83	1.061	2.60	9 98	2 50	4.88	217
11	9 1	.9	1.94	1.48	65 02	1.063	2 35	10 66	2 72	5.59	166
12	9 0	.9	1 81	1.37	63 39	1.006	2.07	11.18	2 83	6.28	170
13	9.1	.9	1.86	1.34	62 99	1.066	2 03	11.40	2.82	6 55	183
14	8.9	.9	1.82	1.32	61.72	1.067	1 88	11.76	2 96	6 92	191
15	8 9	.9	1.81	1.32	60.45	1.067	1 81	11.69	3.15	6.73	217
16	8 7	.9	1.73	1.22	61.20	1.070	1.64	12.40	3 32	7.44	339
17	7 7	.9	1 69	1.25	60.17	1 078	1.56	13 72	4.07	8.09	197
18	8 5	.9	1.44	1.15	62.09	1.069	1.85	11 92	3.42	6.65	191
19*	8.5	1.0	1.81	1.53	56.04	1.080	3.09	12.08	3.62	5.37	30

* This stage (No. 19) was after the cane had ceased growing, late in the season; it was determined frcm canes Nos. 23 and 24 only.

Early Appearance of Sucrose in Juices of Sorghum and Maize.

A preliminary examination of one variety of sorghum, and two of the varieties of maize, was made June 13th, when the plants were about two feet high, and it was found that, even at this early period, there was in their juices an appreciable amount of both sucrose and glucose, as will be seen by the following results:

Juice of White Liberian Sorghum: sucrose, .12 per cent; glucose, .68 per cent.

Juice of Egyptian Sugar Corn: sucrose, .25 per cent; glucose, .94 per cent.

Juice of Lindsay's Horse Tooth Corn: sucrose, .38 per cent; glucose, .98 per cent.

From the above it would seem, that both forms of sugar exist in these plants even in this early stage of development, and that the relative proportions of the two remain about the same for a long time, as will be seen by reference to the tables (page 189). It has, however, not been demonstrated that what is given in the above analyses as sucrose, is such beyond question. It was, however, if not sucrose, at least a substance not precipitated by sub-acetate of lead solution, and without action upon Fehling's solution, until, like sucrose, it had been acted upon by a dilute acid solution. It remains, however, a matter rather of importance in its relation to vegetable physiology, than of practical value as regards the production of sugar from these plants.

The Presence of Sugar in the Stalks of Sorghum, and its Amount at Different Stages of Development.

The fundamental importance of this matter is so great, that any doubts as to the facts set forth in this chapter are to be dispelled by the most conclusive testimony which can be presented.

The following conclusion adopted by a Committee of the National Academy of Sciences, after the mature deliberation of eighteen months and careful consideration of the data, and of the methods by which they were ascertained, can not but be accepted as decisive, and is here given from the Report of the National Academy of Sciences, entitled an "Investigation of the Scientific and Economic Relations of the Sorghum Sugar Industry, by a Committee of the National Academy of Sciences," Nov., 1882, Washington, D. C."

CONCLUSION.

Summary of Results already obtained at the Department of Agriculture, in Washington, D. C., in the Production of Sugar and Molasses from Sorghum and the Stalks of Maize.

The committee find, as the result of their investigation, by all the data which have come before them, as well as those obtained by the Department of Agriculture during the years from 1878 to 1882, both inclusive, and those derived from other parties in different sections of the United States, that the following points are established by an amount of investigation in the laboratory, and of practical experience in the field and factory, which have rarely been devoted to the solution of any industrial problem.

The more important and well established results are here enumerated, and are followed by a statement of certain practical and scientific points which still remain for future inquiry.

A.— OF THE POINTS ALREADY SETTLED.

1. *The Presence of Sugar in the Juices of Sorghum and Maize Stalks.*

From records examined by this committee, it appears that, during the three years prior to 1882, there have been made, at the Department of Agriculture, almost four thousand five hundred chemical analyses of the juices of about forty varieties of sorghum, and of twelve varieties of maize. These analyses have shown the constitution of the juices of each variety at the successive stages in the development of the growing plant. They not only confirm the well known fact of the presence of sugar in the juices of these plants in notable quantity, but they also establish, beyond cavil, what seems surprising to those who have not examined the facts, that the sorghum, particularly, holds in its juices, when taken at the proper stage of development, about as much cane sugar as the best sugar-cane of tropical regions.

An examination of the analytical tables in the reports of Dr. Collier, synopses of which follow, will show that the juices of sorghum, in certain exceptional but not isolated cases, were remarkable for the amount of cane sugar they contained, viz:

Of true crystallizable sugar in the juice—

	Per cent.
5 analyses of 5 varieties gave over	19
33 analyses of 17 varieties gave over	18
79 analyses of 23 varieties gave over	17
152 analyses of 30 varieties gave over	16

As compared with the juices of sugar-cane, which gave, by analysis, under 15 per cent of sugar, these results are unexpected and surprising.

But the average results obtained during long periods of working, and from different varieties, are of more value to the practical farmer than any exceptional instances.

The average results obtained from 122 analyses of 35 different varieties of sorghum, and during a working period of one or another of the above varieties of at least three months in the latitude of Washington, are as follows:

AVERAGE RESULTS OF ANALYSES OF JUICES OF THIRTY-FIVE VARIETIES OF SORGHUM.

	1.	2.	3.	Average
Sucrose .... per cent	15 99	15.94	16.61	16 18
Glucose .... do	1.84	1 72	1 83	1 80
Solids .... do	3 01	3.20	3 01	3 08
Available sugar .... do	11.14	11 02	11 77	11 30
Juice .... do	60.25	58 95	56 51	58 57
Specific gravity of juice	1.082	1.081	1.081	1.0813
Number of analyses	40	37	45	122

From this statement it will be seen, that, as an average of all the analyses made during those three stages, there was obtained 58.57 per cent of the weight of the stripped stalks in juice; that 16.18 per cent of the weight of this juice was crystallizable cane sugar; and that 11.30 per cent of the weight of the juice may be obtained as sugar by the ordinary process of manufacture.*

By reference to the tables it will also be seen, that of the eight varieties of maize examined in 1881, seven of which were of common field and one of sweet corn,

	Per cent of cane sugar.
3 analyses of 3 varieties gave over	13
9 analyses of 7 varieties gave over	12
22 analyses of 7 varieties gave over	11
29 analyses of 7 varieties gave over	10
35 analyses of 7 varieties gave over	9

Of ten varieties of maize grown in 1880, the following results were obtained:

	Per cent of cane sugar.
124 analyses of 10 varieties gave over	9
90 analyses of 10 varieties gave over	10
59 analyses of 9 varieties gave over	11
24 analyses of 9 varieties gave over	12
8 analyses of 4 varieties gave over	13
2 analyses of 1 variety gave over	14
1 analysis of 1 variety gave over	15

Explanation of the Stages of Growth, or of Development.

In order to record as closely as was possible the development of the plants at the time when they were taken from the field for examination, a series of numbers were made use of, which indicated the several stages of development. The determination of stages after the fourteenth was, in the case of the sorghum, difficult, and depended upon the increasing hardness of the seed. These numbers and their significations are as follows:

STAGES OF DEVELOPMENT IN SORGHUM.

1. About one week before opening of panicle.
2. Immediately before opening of panicle.
3. Panicle just appearing.
4. Panicle two-thirds out.

* The "available sugar" here stated, is the amount of cane sugar shown by analysis, less the sum of the glucose and solids not sugar; *e. g.*, in this case 16.18 per cent less (1.80 per cent + 3 08 per cent) = 11.30 per cent. This mode of computation, as has already been explained, gives a less probable quantity of available sugar than is shown by the method of "exponent," usually used by sugar boilers.

5. Panicle entirely out; no stem above upper leaf.
6. Panicle beginning to bloom at the top.
7. Flowers all out; stamens beginning to drop.
8. Seed well set.
9. Seed entering the milk state.
10. Seed becoming doughy.
11. Seed doughy; becoming dry.
12. Seed almost dry; easily crushed.
13. Seed dry; easily split.

AVERAGE RESULTS OF ANALYSES OF ALL VARIETIES OF SORGHUM GROWN AT THE DEPARTMENT OF AGRICULTURE, WASHINGTON, IN 1879, 1880, 1881.

From the general averages of the tables of all the varieties of sorghum, similar in general character to the tables already given by way of illustration, the following tables have been prepared, giving the percentages of sucrose, glucose, solids not sugar, available sugar, and juice; as also the specific gravity and the number of separate analyses made under each stage, for the years 1879, '80, and '81; and, finally, a general average of all the results for the three years.

The same results are graphically represented upon the four charts which follow, the line for juice being left out in the chart giving the results of 1879, since, as has been explained in a previous report, the juice was obtained that year without the aid of a mill, and was so much less in consequence as not to be comparable with the results obtained the last two years. This final chart comprises, as will be seen, the average results of a total of 4,032 separate analyses of some forty-five varieties of sorghum, and, covering the record of three years' work, the results are the more conclusive.

AVERAGE RESULTS FOR 1879, 1880, 1881.

Development.	Per cent sucrose.			Per cent glucose.			Per cent solids.		
	1879.	1880.	1881.	1879.	1880.	1881.	1879.	1880.	1881.
First stage	....	1.76	.89		4 29	2.31	....	1.75	2 40
Second stage	1.20	2.96	1 20	5 13	4 45	3 24	....	1 86	2 41
Third stage	....	3 51	1.84	..	4 50	3 35	....	1 78	2 41
Fourth stage	....	4.34	2 02	..	4 34	3.41	...	1 91	2 90
Fifth stage	3 94	5 13	2 78	4.65	4.15	3 41	1.40	1 92	3 18
Sixth stage	3.62	6.50	3 60	5.55	3.99	3 69	1 56	2 45	2 78
Seventh stage	7 07	7 38	4 71	3.87	3 86	3 88	1 71	2 19	2 81
Eighth stage	6 18	7 69	6 08	4 47	3.83	3 69	1 36	2 37	3 03
Ninth stage	9 72	8.95	7 47	3 60	3 19	3 70	1 45	2.42	2 63
Tenth stage	8 04	9.98	8 76	3.27	2 60	3 30	1 53	2 50	2 60
Eleventh stage	11 54	10 66	10.00	2.81	2 35	2 96	1 42	2 72	2 90
Twelfth stage	14.15	11 18	12 01	1 58	2 07	2 74	2 52	2.83	2 93
Thirteenth stage	14 37	11.40	13 06	1 46	2 03	2 47	1 51	2 82	2 98
Fourteenth stage	12.44	11 76	13 98	1.16	1 88	2 21	2 93	2 96	2 90
Fifteenth stage	14.26	11 69	14 34	1 74	1 81	2.22	3 01	3 15	2 88
Sixteenth stage	14 37	12 40	15 99	1.12	1 64	1 84	2.02	3 32	3 01
Seventeenth stage	13 84	13 72	15 94	.93	1 56	1.72	3 13	4 07	3 20
Eighteenth stage	8.45	11 92	16 61	.70	1 85	1 83	3 22	3 42	3.01
Nineteenth stage	14 75	12 08	15 23	.82	3 09	1 75	2 60	3.62	3 65
Twentieth stage	14.13	....	11.89	1.50	....	1.73	3.13	.....	3.83

Average Results for 1879, 1880, 1881.—*Continued.*

Development.	Specific gravity.			Per cent of juice.			Per cent available sugar.		
	1879.	1880.	1881.	1879.	1880.	1881.	1879.	1880.	1881.
First stage	...	1.031	1 018	. .	59.06	65.30	...	—4.28	—3.82
Second stage	1.035	1.036	1.025	34 40	59 60	67.13	—3 93	—3.35	—4 45
Third stage..	.....	1.037	1.029	......	59.67	69.48		—2 77	—3 92
Fourth stage..	.....	1 041	1 029	......	61.61	68.02	. .	—1 91	—4 29
Fifth stage	1.043	1 045	1 032	35.81	63.05	68 18	—2 15	— .94	—3 81
Sixth stage	1.044	1 050	1 035	35.20	62.79	68.07	—3.49	.06	—2 87
Seventh stage	1 061	1.052	1.042	36 65	63.85	67.21	1 49	1.33	—1.98
Eighth stage	1.061	1.055	1.048	33 80	65 68	67.81	35	1.49	— .64
Ninth stage..	1.063	1.058	1 052	32.70	64.88	66.76	—4.67	3 34	1.14
Tenth stage	1 061	1.061	1 056	34 91	64 83	67 91	3 24	4 88	2 86
Eleventh stage	1.068	1.063	1 061	34 35	65 02	65 84	7 31	5 59	4.14
Twelfth stage	1 081	1.065	1 068	31 72	63 39	62 44	10 05	6 28	6 34
Thirteenth stage..	1.082	1 066	1 071	30 07	62 99	62 50	11 40	6 55	7.61
Fourteenth stage..	1 080	1.067	1 075	30.73	61 72	58 92	8 35	6.92	8.87
Fifteenth stage..	1.078	1.067	1 077	29 50	60 45	63 54	9 51	6.73	9.24
Sixteenth stage	1.077	1.070	1.082	27.57	61 20	60 25	11.23	7.44	11 14
Seventeeth stage	1.078	1 078	1 081	21.60	60 17	58 85	9 78	8 09	11 02
Eighteenth stage..	1 081	1.069	1 082	26.20	62 09	56 51	4 53	6 65	11 77
Nineteenth stage..	1 077	1 080	1.080	22 95	56.04	57 22	11 33	5 37	9 83
Twentieth stage.	1.079	.....	1.069	25.22	..	58 45	9.50	.	6 79

Development.	No. of analyses.			Average results, 1879, 1880, 1881.						
	1879.	1880.	1881.	Sucrose.	Glucose.	Solids.	Specific gravity.	Juice.	Available sugar.	Number of analyses.
				Pr.ct.	Pr ct.	Pr ct.		Pr ct.	Pr ct.	
First stage..	......	58	16	1.57	3 86	1.89	1 028	60.41	—4.18	74
Second stage.	2	69	38	2.32	4.03	2.05	1 032	62 26	—3 76	109
Third stage	......	57	40	2 82	4 02	2 04	1 033	63 71	—3 24	97
Fourth stage.	......	70	52	3.35	3 94	2 33	1.035	64 34	—2 92	122
Fifth stage.	8	75	46	4 23	3 89	2.36	1 043	65 00	—2.02	129
Sixth stage..	4	62	51	5 16	3 88	2 58	1 045	65.17	—1.30	117
Seventh stage	4	70	42	6 39	3 85	2 41	1 048	65.11	.13	116
Eighth stage.	4	111	42	7.23	3.80	2.53	1 053	66.25	.90	157
Ninth stage	4	266	45	8 74	3 26	2 44	1 057	65 15	4.04	315
Tenth stage	8	217	60	9.69	2 76	2 50	1 060	65 49	4.49	285
Eleventh stage.	12	166	53	10 53	2 50	2 72	1 062	65.22	5.31	230
Twelfth stage	10	170	44	11.41	2 19	2 84	1 066	63.19	6 38	224
Thirteenth stage.	8	183	40	11.75	2.09	2 82	1 068	62 90	6 84	231
Fourteenth stage	8	191	37	12 13	1 92	2.95	1 068	61.26	7 26	236
Fifteenth stage.	4	217	37	12 09	1 87	3 11	1 068	60 90	7 11	258
Sixteenth stage	6	339	40	12.79	1 65	3 28	1 071	61 10	7.86	385
Seventeeth stage.	6	197	37	14.07	1 57	3 92	1 078	59 98	8.58	240
Eighteenth stage	2	191	45	12 80	1 71	3 34	1 071	61 03	7 75	238
Nineteenth stage	12	30	44	14 01	2 18	3.31	1 080	56 74	8 52	86
Twentieth stage.	22	....	370	11.95	1.72	3 81	1 069	58 45	6.42	392
Total.	124	2,739	1,179	.. ..	....	.....	. ...	.....	.....	4,042

Graphical Charts.

The preceding results will appear more clearly by representing them graphically; and in the following charts the percentage is indicated, for the sucrose, glucose, solids not sugars, and available sugar, by the numbers given upon the right and left hand margins, while the dates

are given upon the upper margin of each sheet. For convenience of platting upon the same sheet, the per cent of juice given upon the charts should be multiplied by five in every case, and the specific gravity is represented by having .001 in specific gravity equal to one-fifth of one per cent as given upon the chart.

Each point indicated by a break in either of the lines representing the above constituents, the specific gravity or the juice, represents the average result actually obtained in the several analyses of a juice at any given stage of development. The beginning of each line and the end represent the average results of the first and last stages, and the intervening breaks the successive stages from the first to the last:

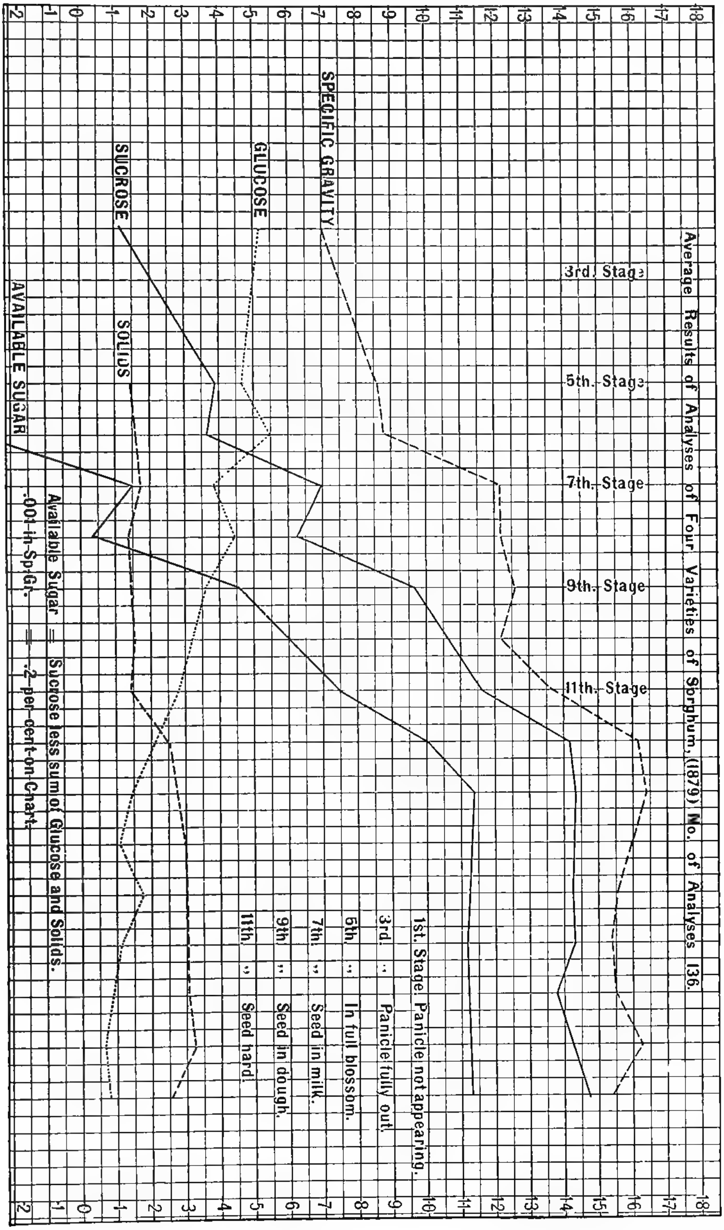

Average Results of Analyses of Four Varieties of Sorghum, (1879) No. of Analyses 136.
3rd. Stage
5th. Stage
7th. Stage
9th. Stage
11th. Stage
SPECIFIC GRAVITY
GLUCOSE
SUCROSE
SOLIDS
AVAILABLE SUGAR
1st. Stage. Panicle not appearing.
3rd. " Panicle fully out.
5th. " In full blossom.
7th. " Seed in milk.
9th. " Seed in dough.
11th. " Seed hard.
Available Sugar = Sucrose less sum of Glucose and Solids.
.001 in Sp. Gr. = .2 per cent on Chart.

Plate XVIII.

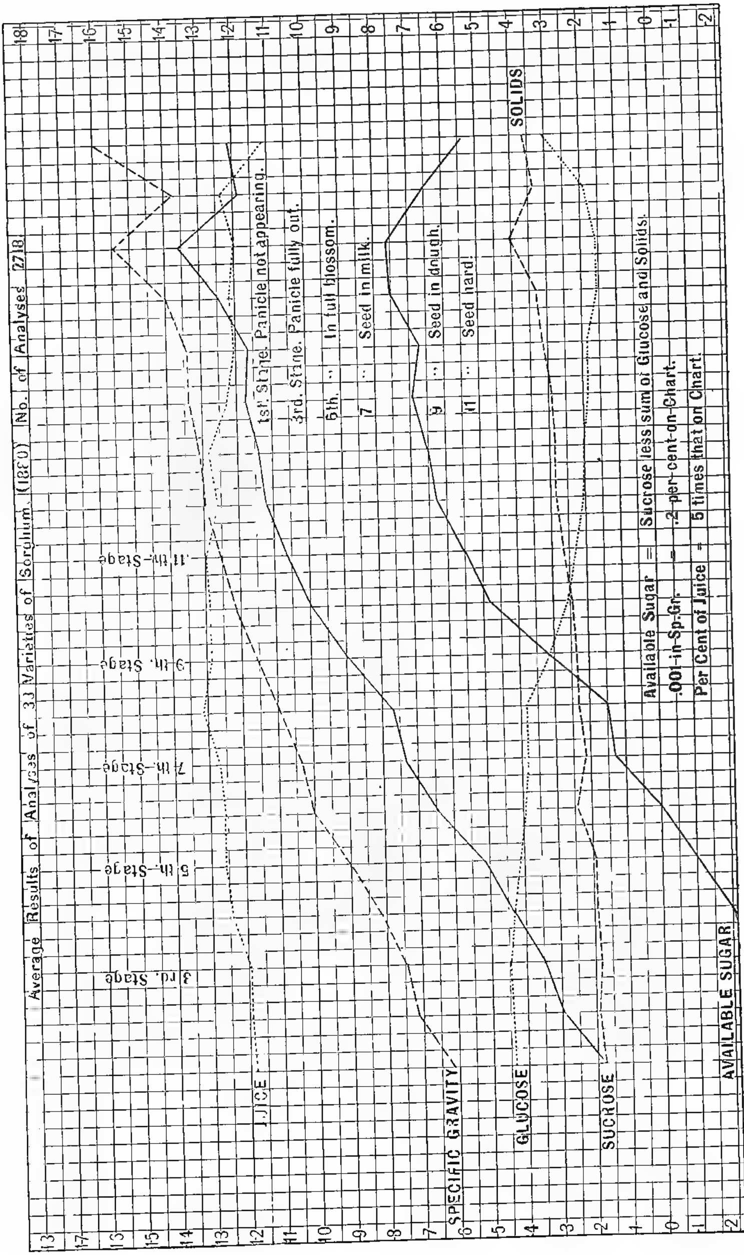

Average Results of Analyses of 33 Varieties of Sorghum, (1880) No. of Analyses 2718.
1st. Stage. Panicle not appearing.
3rd. Stage. Panicle fully out.
6th. " In full blossom.
7 " Seed in milk.
9 " Seed in dough.
11 " Seed hard.
Available Sugar = Sucrose less sum of Glucose and Solids.
.001 in Sp. Gr. = .2 per cent on Chart.
Per Cent of Juice = 5 times that on Chart.
SOLIDS
JUICE
SPECIFIC GRAVITY
GLUCOSE
SUCROSE
AVAILABLE SUGAR
3 rd. Stage
5 th. Stage
7 th. Stage
9 th. Stage
11 th. Stage

Plate XIX.

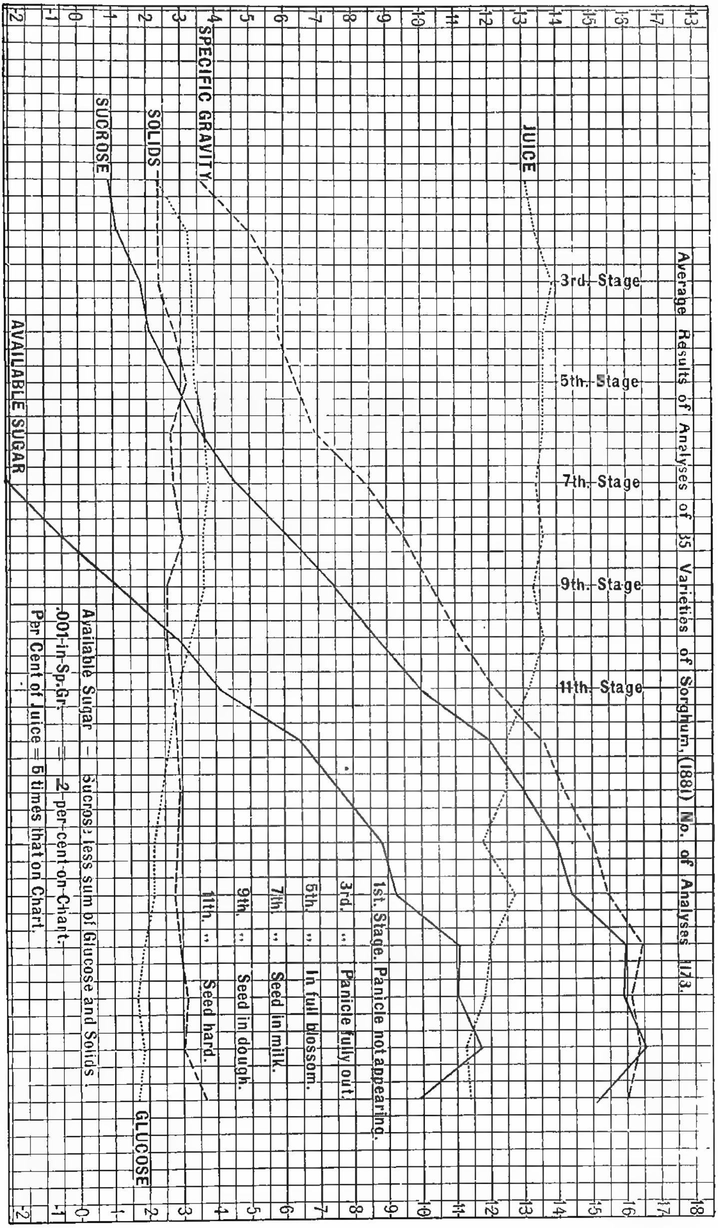

Average Results of Analyses of 35 Varieties of Sorghum, (1881) No. of Analyses 173.
3rd. Stage
5th. Stage
7th. Stage
9th. Stage
11th. Stage
JUICE
SPECIFIC GRAVITY
SOLIDS
SUCROSE
AVAILABLE SUGAR
GLUCOSE
1st. Stage. Panicle not appearing.
3rd. " Panicle fully out.
5th. " In full blossom.
7th. " Seed in milk.
9th. " Seed in dough.
11th. " Seed hard.
Available Sugar = Sucrose less sum of Glucose and Solids.
.001 in Sp. Gr. = .2 per cent on Chart.
Per Cent of Juice = 5 times that on Chart.

Plate XX.

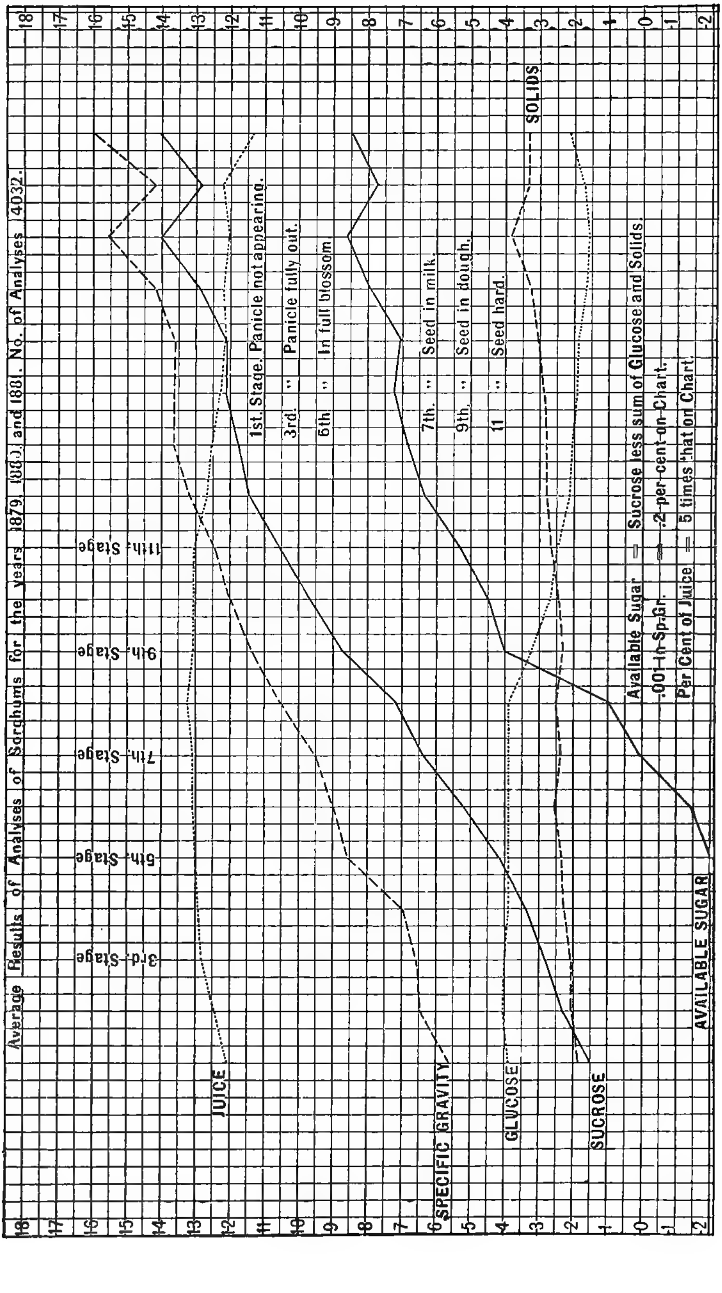

Average Results of Analyses of Sorghums for the years 1879, 1880 and 1881. No. of Analyses 4032.
1st. Stage. Panicle not appearing.
3rd. " Panicle fully out.
6th " In full blossom.
7th. " Seed in milk.
9th. " Seed in dough.
11 " Seed hard.
Available Sugar = Sucrose less sum of Glucose and Solids.
.001 th Sp. Gr. = .2 per cent on Chart.
Per Cent of Juice = 5 times that on Chart.
3rd Stage
5th Stage
7th Stage
9th Stage
11th Stage
JUICE
SPECIFIC GRAVITY
GLUCOSE
SUCROSE
AVAILABLE SUGAR
SOLIDS
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2

Plate XXI.

In 1882, there were grown upon the grounds of the Department of Agriculture, at Washington, 78 varieties of sorghum, consisting largely of varieties quite new to the United States, from South Africa, China, and India. The Chinese varieties, and several of those from Africa, proved to be comparatively worthless for sugar; but, since the average results of the entire number grown and examined during the season only serves to confirm fully the results already recorded as to the gradual increase of sugar in these plants, the analyses are here given:

AVERAGE RESULTS OF ANALYSES AT DIFFERENT STAGES OF DEVELOPMENT.—78 VARIETIES GROWN IN 1882.

No. of analyses.	DEVELOPMENT.	Per cent of juice.	Specific gravity.	Per cent glucose.	Per cent sucrose.	Per cent solids.	Polarization.	Per cent available sugar.
2	Head swelling	66.97	1.034	3.255	3.78	1.275	3 98	—0 75
4	Head fully out	63.04	1.040	4.398	3.85	1 265	4.195	—1.813
2	Before bloom	60.22	1.044	4 59	5 14	1.50	5.77	—0 95
6	In full bloom	63.90	1.049	3.89	6.47	1.67	6.64	0 88
21	After bloom	63.77	1.050	3.32	7.38	2.17	6 56	1.85
85	Seed in milk	60.88	1.055	2 90	8 45	2.41	8 87	3.20
187	Seed in dough	58.11	1.0606	2.171	9 88	2.656	9.80	5 054
206	Seed hard	58 07	1 0627	1 33	10 48	2 885	10.447	6 233
94	Sucker seed in milk	56.71	1.0668	1.203	11.418	3 274	11.603	7.426
199	Sucker seed in dough	58 06	1.070	1 12	12.25	3.10	12.40	8.19
134	Sucker seed hard	52.90	1.0731	1.45	12.63	3.52	12.33	8.56

Comparison with Foreign Varieties.

In 1882, examinations were made of a large number of varieties quite new to this country, from seed received from Africa, China, and India, and the results of these analyses are given by themselves for the purpose of comparison with the analyses of those varieties which have been cultivated in the United States for the past thirty or thirty-five years.

Comparative Value during Working Period (i. e., after seed was hard) of 14 Chinese, 26 African, 3 Indian, and 20 American Varieties of Sorghum, see page 102.

PER CENT AVAILABLE SUGAR IN JUICES.

Chinese	4.89	per cent.
African	7.19	"
Indian	6.93	"
American	7.90	"

Analyses of Other Varieties of Sorghum (Sorghum Vulgare).

The following analyses will show how widely these varieties of sor-

ghum under consideration differ in composition and in value, as sources of sugar, from other members of the Sorghum family to which, botanically, they are so closely allied:

ANALYSES.—JUICES BROOM CORNS.

Variety.	*No. Anal.*	*Sucrose. pr. ct.*	*Glucose. pr. ct.*	*Solids. pr. ct.*
Valley....	6	1.45	1.55	2.25
Chinese Evergreen......	5	2.40	2.25	2.49
Evergreen	4	2.50	1.97	2.40
Average.............	15	2.12	1.92	2.38

ANALYSES.—JUICES DOURA CORNS.

Variety.	*No. Anal.*	*Sucrose. pr. ct.*	*Glucose. pr. ct.*	*Solids. pr. ct.*
Rice, or Egyptian........	17	6.57	.84	3.49
Doura.....................	6	5.77	2.33	2.71
Brown Doura............	2	3.70	1.75	8.70
White Doura.	1	8.70	1.90	7.00
Average............	26	6.19	1.71	5.48

Comparison of Sugar-Cane with Sorghum.

The results represented upon the tables and charts which have been given, will appear the more surprising if compared with the average analyses of the juices of sugar-cane.

Analyses af Louisiana Cane.

The following analyses of specimens of Louisiana cane, were made at the Department of Agriculture, by the same methods pursued in the analyses of the sorghum; so the results are entirely comparable.

LOUISIANA SUGAR-CANES.

Date,	Variety.	Portion.	Number of stalks.	Total weight, in pounds.	Weight of leaf top.	Weight of bare cane.	Weight of top, stripped.	Total length to end of leaves, in feet.	Length of bare cane.	Length of leaf top, stripped.	Diameter at butt, in feet.	Diameter at first leaf.	Number of joints in butt.	Number of joints in middle.	Length of first joint.	Length of second joint.	Length of middle joint.	Length of first leaf-joint.	Per cent of water in cane.	Weight of juice, in pounds.	Specific gravity of juice.	Per cent of solids in juice.	Glucose, per cent of, in juice.	Sucrose, per cent. of, in juice.	Per cent of solids not sugar, in juice.	Polarization, per ct., sucrose.
Nov. 11	Ribbon-cane plant, '79	Top																	85.51	.668	1.036	7.36	4.08	1.57	.71	7.08
Nov. 11	...do...	Middle																	79.19	2.919	1.056	13.62	1.98	11.30	.34	11.13
Nov. 11	.. do...	Butt	2	13.23	2.68	10.55	1.07	13.12	6.72	1.34	.124	.118	8	10	.291			.262	80.11	3.025	1.063	15.28	.71	...	...	13.97
Nov. 11	...do...	Top																	84.90	.366	1.040	8.82	4.29	2.83	1.70	....
Nov. 11	...do...	Middle																	78.18	1.464	1.057	13.79	1.61	11.30	.88	....
Nov. 11	...do...	Butt	1	6.00	1.19	4.81	.68	12.89	6.99	1.57	.124	115	9	11	.239		.426	.220	76.19	1.486	...	...	.81	13.64	....	....
Nov. 11	do...	Top																	81.81	.761	1.031	10.96	2.94	6.30	1.72	5.97
Nov. 11	Ribbon-cane plant, '78	Middle																	91.90	2.381	1.067	16.31	.68	15.82	....	15.79
Nov. 11	.. do...	Butt	2	10.26	2.63	7.63	1.35	11.81	5.81	1.57	127 / 124	.112	6	9	.164 / 295	.246 / .361		.262 / .164	71.63	2.055	1.074	17.71	.45	17.17	.09	17.00
Nov. 11	Red cane, 1878...	Top																	81.97	.739	1.047	10.32	3.41	2.14	4.77	5.06
Nov. 11	do...	Middle																	75.67	2.795	1.064	15.59	1.41	13.36	.82	14.07
Nov. 11	...do...	Butt	2	11.65	2.30	9.35	1.30	11.48	6.47	1.71	131 / .115	108			.203			.148	78.22	3.113	1.066	15.69	1.04	15.26	.39	14.59

ANALYSES OF SUGAR-CANE JUICES BY REGINALD M. SANDYS.

A. Ribbon Cane, Sagua la Grande.
B. Second years' stubble.
C. Red Plant Cane.
D. First year's stubble—one-half red, one-half ribbon.
E. Creole Cane.
F. Japanese Cane.

	A.	B.	C.	D.	E.	F.
Average weight of canes............ pounds....	3.03	2.31	4.12	2.56	1.31	1.67
Specific gravity juice................ Beaume...	8.6°	8.5°	8.4°	8.6°	6 5°	7.0°
Per cent sucrose....	12.80	13.17	12.52	13.60	4.51	4.93
Per cent glucose	1.52	.82	1 14	.90	7.19	7.68
Per cent mineral and vegetable matter	1.14	1.09	1.18	1.00	....	...
Quotient of purity	.82	.86	.84	.87	.39	.39

For purpose of further comparison, the following analyses of sugar-canes and juice of the sugar-cane grown in Madras, India, are given below. The canes were divided into upper, middle, and lower thirds: each third being two feet in length, except the lower thirds of the selected canes, which were three feet in length:

	Bundle of medium good canes.			Bundle of selected canes.		
	Upper third.	Middle third.	Lower third.	Upper third.	Middle third.	Lower third.
Bagasse	7.630	8 470	8 300	7.580	8 650	8 290
Sucrose	10 630	13 310	13.370	9 490	13.640	13.850
Glucose	2.640	1.510	1 540	2 430	.736	.710
Ash	.307	.259	.233	.545	.363	.349
Water	78.334	75 612	76 122	79 484	75.628	75 945
Undetermined	.459	.839	.455	.471	.983	.856
	100 000	100.000	100.000	100.000	100.000	100.000

ANALYSES OF EXPRESSED JUICE.

Sucrose	11 510	14.550	14.580	10 270	14.930	15.110
Glucose	2.860	1.650	1.680	2.630	.806	.775
Ash	.333	.283	.255	.590	.398	.381
Undetermined	.497	.917	.485	.510	1.076	934
Water	84.800	82.600	83.000	86.000	82.790	82.800
	100.000	100.000	100.000	100.000	100.000	100.000

CHEM. CENT. BLATT., *February, 1880.*

AVERAGE ANALYSIS OF ELEVEN SUGAR-CANES.

Water	73.74	per cent.
Sugar	15.07	per cent.
Fiber	9.51	per cent.
Salts	.36	per cent.
Other solids	1.32	per cent.
	100.	

Twenty-five samples of sugar-cane juices, from the many varieties of this plant grown in Louisiana, Cuba, Jamaica, Martinique, Guadalupe, and the East Indies, analyzed by several chemists, give the following average composition: Sucrose, 13.28 per cent; other solids, 2.71 per cent. If, now, as in the case of the sorghums, we subtract the sum of the solids (which was made up of ash, glucose, and other undetermined substances) from the sucrose, we have, as available sugar in these juices, an average of 10.57 per cent—an amount even less than that found present in the average juice of thirty-five kinds of sorghum for long periods, as will be seen by reference to the charts and tables.

Analysis of Juice at Different Stages.

It has been supposed by some, that the increase in the amount of sugar at certain periods is due to the drying up of the plant, and the consequent concentration of the juice by evaporation.

This view, although apparently supported by some facts, is probably erroneous, since (as will appear from the results of our determinations, as shown upon either of the charts showing the average results for a year) the amount of juice varies but little during the year; but, owing to continuous increase in the sucrose, glucose, and other solids, during the season (as shown by the analyses, and indicated by the steady increase in specific gravity), it follows, of necessity, that the amount of water in the juice must as steadily decline.

This, however, would hardly appear as the result of a drying up of the plant; since, as has been shown, neither the amount of juice, nor its composition, suffers any great change, even when a heavy rain-fall succeeds a period of prolonged drought.

It appears rather a normal condition of the plant's growth; and the production of sugar seems to be accompanied by the elimination of a certain amount of water.

If, at any time, we might look for more concentration of juice by the evaporation of water, and the consequent increase in the percentage of the several constituents of the juice, it would seem to be during the later periods of the plant's growth. If, now, we take the results for the past season, as given in the general averages, we find that, for example, the amount of total solids obtained in the juice were, in the fifteenth, sixteenth, and seventeenth stages, 12.35, 12.56, and 12.30 per cent of the weight of the stripped stalks; but the amount of water in the juices at these periods was, for these respective stages, 51.19, 47.69, and 46.65 per cent of the weight of the stripped stalks.

As will be seen, there is, in the above results, a slow diminution of water, but no corresponding increase of the solids.

The following table gives the results for the season of 1881, showing the per cent of juice, and of each of its constituents, as also of available sugar, calculated to the stripped stalks:

PERCENTAGE OF SUCROSE, TOTAL SOLIDS, WATER, AND AVAILABLE SUGAR, IN STRIPPED STALKS, OBTAINED IN JUICE AT DIFFERENT STAGES.

STAGES.	Per cent of juice obtained.	Specific gravity.	Per cent of total solids.	Per cent of water.	Per cent of sucrose.	Per cent of available sugar.	Pounds of available sugar in one ton of stripped stalks.	Number of analyses.
1	65.30	1.018	3.66	61.64	.58	....	....	16
2	67.13	1.025	4.60	62.53	.81	....	....	38
3	69.48	1.029	5.28	64.20	1.28	....	....	40
4	68.02	1.029	5.67	62.35	1.37	....	....	52
5	68.18	1.032	6.39	61.79	1.90	....	....	46
6	68.07	1.035	6.85	61.22	2.45	....	....	51
7	67.21	1.042	7.96	59.55	3.17	....	....	42
8	67.81	1.048	8.68	59.13	4.12	....	....	42
9	66.76	1.052	9.21	57.55	4.99	.76	15.20	45
10	67.91	1.056	9.96	57.95	5.95	1.94	38.80	60
11	65.84	1.061	10.44	55.40	6.58	2.73	54.60	53
12	62.44	1.068	11.04	51.40	7.50	3.96	79.20	44
13	62.50	1.071	11.57	50.90	8.16	4.76	95.20	40
14	58.92	1.075	11.25	47.67	8.24	5.23	104.60	37
15	63.54	1.077	12.35	51.19	9.11	5.87	117.40	37
16	60.25	1.082	12.56	47.69	9.63	6.71	134.20	40
17	58.95	1.081	12.30	46.65	9.40	6.50	130.00	37
18	56.51	1.081	12.12	44.39	9.39	6.65	133.00	45
19	57.22	1.080	11.80	45.42	8.71	5.62	112.40	43
20	58.45	1.069	10.20	48.25	6.95	3.97	79.40	370

It will be seen in the foregoing table, that there is an uninterrupted increase in the percentage of sucrose, total solids, available sugar, and specific gravity, with a corresponding decrease in the percentages of water, to about the sixteenth stage. During the sixteenth, seventeenth, and eighteenth stages, the per cent of available sugar in the stalks remains nearly constant, and at its maximum; although the per cent of sucrose and of available sugar in the juice obtained, as has been shown, is at its maximum at the eighteenth stage.

The number of pounds of available sugar to be obtained from a ton of stalks, at the different stages, is also given in a separate column. From these results, it would appear, as the average result of 122 analyses of thirty-five varieties of sorghum, that 133 pounds of sugar from a ton of stripped stalks is not beyond the limits of even probability. It will also be seen that these same stalks, if cut while the seed is in a doughy condition, as shown by the ninth stage, would yield only 15 pounds of sugar per ton of stalks.

Practically Little Difference in the Varieties of Sorghum as to their Content of Sugar.

The results of the investigations at the Department of Agriculture have shown the remarkable uniformity of the several varieties of sorghum as sugar producing plants when fully developed; and have also shown the different varieties to vary widely in the time required for their full development, varying, as has been shown, year after year, fully three months as between the earlier and later maturing varieties.

This fact of the wide variation in different varieties in their period of reaching full maturity, although previously recognized, has not received the consideration which its extreme importance demanded, as is evinced by the fact, that at present, as for the past thirty years, those varieties are largely grown in the northern states which could only reach maturity at rare intervals and in exceptional seasons in these latitudes. This satisfactorily accounts for the occasional production of crystallizable sirups, and the general failure to secure similar results continuously.

Comparative Value, During the Working Period of the Different Varieties of Sorghum.

From the following table it is possible to judge quite accurately as to the comparative values of the different canes for the production of sugar. These values are applicable more especially to the latitude of Washington, and it will be seen later that certain canes which do not stand high in the list, when grown in this section, are very likely to prove valuable where the growing season is longer.

Again, those which mature quickest, and also have a long working period, are the ones especially recommended for culture in more northern latitudes.

In this table the canes are arranged in the order of their comparative value, as shown from the large number of analyses recorded. It must not be inferred, however, that it is possible to state positively that this order may not be somewhat modified by future experience: it certainly would be somewhat changed were any one characteristic of the juice used as the basis of comparison to the exclusion of all others. It has been attempted to give due weight to all the factors which tend to show the good or bad qualities of the canes.

Among the points which have the most direct bearing on the determination as to the value of any cane for any locality are the following:

1. Other things being equal, that cane is best adapted to any local-

ity which most quickly reaches the working stage, and longest continues workable. It will be noticed that, judged by this rule, the first eight varieties are superior to those that follow. It appears, also, that these varieties matured in from 77 to 89 days, and continued workable from 87 to 107 days, or, on an average, over *three months.* It is very important to have sufficient time in which to work up the crop.

2. The *average purity of the juice* is another very important consideration. This is shown by the column headed "average exponent;" by this term is meant the percentage of pure crystallizable sugar in the total solids of the juice. As has already been stated in the discussion of the table of specific gravities, the exponent should not fall below 70 for the best results.

3. The *average available sugar in the juice* has very much to do with its value. The figures in this column were calculated by multiplying the figures in the column showing "average per cent sucrose in juice" by the corresponding figures for "average exponent."

4. The *pounds of juice per acre* has much to do with the amount of sugar that can be obtained.

As will be seen, the various canes do not differ very materially in the percentage of juice they can furnish; hence, the pounds of juice per acre depend more directly upon the number and weight of canes which can be raised. By reference to the tables for each variety, it will be seen that several of the varieties standing low in this list (Honduras, Honey Top, etc.), furnish canes much heavier than those standing near the first of the list; hence, if an equal number of such heavy canes could be grown on an acre, the amount of juice must be correspondingly greater.

If, then, the quality of the juice from heavy canes is as good as that from the light, and the season for working is greater, the heavy canes would be preferable, because they would furnish the larger amount of sugar per acre. Unfortunately, this is not the case in this latitude. The first two columns in this table show, that the heavier canes do not attain their full growth and maturity in time to be worked up into sugar.

It is fully believed that these heavy canes are well adapted to the more southern parts of the United States, and that in those regions they will reach full maturity in time to leave an ample working period. In fact, several examinations of canes sent from South Carolina in 1879 confirm these statements.

If it be supposed, for the sake of comparison, that an equal number of canes of each variety can be grown on an acre of land, the results

given in the last three columns will show what amounts of stripped stalks, juice, and available sugar, can be obtained on an acre from each variety of sorghum. The number of stalks per acre has been placed at 24,000, which is believed to be a fair estimate.

In comparing these figures with those in the three columns just preceding them, which represent actual results of analyses, it will be seen that the figures do not differ greatly.

6. After all, the real test of value for any cane, is the amount of crystallizable sugar that can be actually separated from the juice obtained from the stalks grown on an acre. This amount will depend very greatly on the quantity and quality of the canes, and upon the promptness and care with which they are worked up after cutting. The figures here given in explanation of the various points which have been discussed, have been derived from very carefully conducted work, and they are offered as fair statements of what can and should be attained by careful workers.

Among the essential points worthy of repetition are the following:

1. Select a cane that matures quickly, and has as long a working period as possible.

2. Do not work the cane too early; the seed should be well matured and quite hard, and the juice should have a specific gravity of 1.066 or higher.

3. After cutting the canes, work them up without great delay. It is best to draw directly from the field to the mill as may be needed.

TABLE SHOWING THE COMPARATIVE VALUE, DURING THE WORKING PERIOD, OF ALL VARIETIES OF SORGHUM EXAMINED AT THE DEPARTMENT OF AGRICULTURE, WASHINGTON, IN 1880.

Name.	Source of seed.	No. of days to maturity.	No. of days for working.	No. of analyses.	Average per cent sucrose in juice.	Average per cent glucose in juice.	Average per cent other solids in juice.	Aver. exponent.	Average per cent available sugar.	Average per cent juice.	Actually obtained.			Computed at 24,000 stalks per acre.		
											Stripped stalks, per acre.	Juice, per acre.	Available sugar, per acre.	Stripped stalks, per acre.	Juice, per acre.	Available sugar, per acre.
Varieties of Sorghum.											*Lbs.*	*Lbs.*	*Lbs*	*Lbs.*	*Lbs*	*Lbs.*
Early Amber	D. Smith	77	99	80	12.42	1.55	2.98	73.15	9.11	60.02	27,073	16,249	1,480	25,520	15,317	1,395
Early Amber	Plant Seed Company	80	99	70	12.00	1.51	3.18	71.72	8.67	61.33	29,808	18,281	1,585	24,480	15,023	1,302
Early Golden	A. B. Swain	80	104	76	11.17	1.76	3.09	70.24	8.12	60.03	24,611	14,774	1,200	24,480	14,695	1,352
Golden Syrup	W. H. Lytle	87	82	67	12.48	1.42	2.99	73.65	9.24	61.36	15,822	9,708	897	24,480	14,023	1,388
White Liberian	D. Smith	88	101	39	13.43	1.31	3.17	74.98	10.08	63.82	32,165	20,528	2,069	31,920	20,371	2,053
Early Amber	S. E. Evans	89	96	24	13.21	1.54	3.28	73.23	9.69	59.02	27,952	16,503	1,599	23,760	14,023	1,359
Black Top	D. W. Aiken	87	87	35	12.69	1.21	3.07	74.75	9.51	61.35	21,907	13,440	1,278	22,800	13,977	1,329
African	W. E. Parks	87	107	83	11.50	1.46	3.14	70.38	8.13	62.92	21,716	13,664	1,111	27,840	17,517	1,424
White Mammoth	Amos Carpenter	102	83	32	13.51	1.18	3.45	74.50	10.13	62.31	29,341	18,282	1,851	31,680	19,740	1,999
Oomseeana	Blymyer & Co.	115	77	54	12.16	1.49	3.07	72.43	8.81	64.15	19,522	12,523	1,103	27,840	17,859	1,573
Regular Sorgho	Blymyer & Co.	101	93	71	11.80	1.49	3.03	72.27	8.70	60.77	26,611	16,172	1,407	30,720	18,669	1,624
Hybrid	E. Link	101	84	30	14.24	.93	3.43	76.08	10.84	63.53	34,447	21,903	2,374	42,240	26,835	2,909
Sugar Cane	J. W. Barger	108	77	28	13.82	1.49	3.13	74.18	10.27	62.32	21,117	13,150	1,350	21,600	13,461	1,382
Oomseeana	D. W. Aiken	104	88	35	12.84	1.12	3.31	74.21	9.57	62.04	22,825	14,150	1,355	28,080	17,420	1,667
Neeazana	W. H. Lytle	136	58	38	13.16	1.93	3.18	72.13	9.48	61.58	23,467	14,451	1,360	26,400	16,257	1,441
Goose Neck	P. P. Ramsey	111	72	44	12.26	1.46	2.99	73.29	7.58	62.12	27,362	16,997	1,288	30,480	18,934	1,435
Early Orange	I. A. Hedges	117	79	53	13.18	1.58	3.39	72.45	9.56	61.67	48,758	30,069	2,875	35,520	21,903	2,094
Neeazana	Blymyer & Co	129	65	46	13.45	1.95	3.11	72.77	9.78	60.52	20,156	12,198	1,193	25,200	15,241	1,491
New Variety	E. Link	108	84	31	12.84	1.19	3.35	73.93	9.50	65.22	30,731	20,042	1,904	28,320	18,470	1,755
Chinese	D. Smith	137	57	36	13.18	1.81	3.68	70.66	9.22	60.43	30,956	18,707	1,725	32,720	19,773	1,823
Wolf Tail	E. Link	118	56	21	11.72	1.23	2.98	71.87	8.65	62.09	31,493	19,554	1,691	30,960	19,223	1,663
Gray Top	H. C. Sealey	135	59	33	13.03	1.47	3.54	72.19	9.42	63.00	29,887	18,809	1,772	28,800	18,144	1,709
Liberian	Blymyer & Co.	131	38	22	13.18	2.05	3.22	71.23	9.39	62.02	45,580	28,269	2,654	45,120	27,983	2,628
Liberian	W. H. Lytle	134	48	36	12.92	2.09	3.37	70.31	9.08	62.56	44,913	28,088	2,550	44,400	27,777	2,522
Oomseeana	W. I. Mayes & Co.	127	67	36	13.62	1.71	3.40	72.50	9.88	61.89	35,414	21,918	2,165	42,480	26,291	2,588
Sumac	W. Pope	152	31	14	14.24	1.67	4.18	70.82	10.09	60.15	39,919	24,011	2,423	39,360	23,675	2,389
Mastodon	D. W. Aiken	128	60	23	11.24	1.68	3.03	69.93	7.95	64.27	20,413	13,119	1,043	47,760	30,695	2,440
Imphee	D. W. Aiken	155	37	9	14.21	1.76	3.61	72.56	10.31	61.67	37,031	22,837	2,354	37,920	23,385	2,411
New Variety	J. W. H. Salle	172	7	5	13.99	2.02	3.73	70.88	9.92	58.57	26,090	15,287	1,516	25,920	15,181	1,506
Sumac	J. H. Wighton	168	20	6	14.40	1.80	3.40	73.53	10.58	60.84	39,815	24,223	2,563	36,960	22,486	2,388
Honduras	Arsenal	148	29	27	10.32	2.26	3.09	65.76	6.81	57.09	25,335	14,464	985	29,760	16,990	1,157
Honey Cane	J. H. Clark	133	43	21	10.80	2.56	2.51	67.76	7.37	65.08	50,017	30,301	2,233	53,760	34,987	2,579
Sprangle Top	W. Pope	153	38	20	11.21	2.61	2.94	66.79	7.51	65.91	46,634	30,736	2,308	44,880	29,580	2,221
Honduras	E. Link	157	10	4	12.83	1.80	2.95	72.98	10.06	65.06	45,695	29,729	2,991	50,740	33,011	3,321
Honey Top, or Texas Cane	Brussels, Mo.	163	20	7	12.98	2.11	3.92	66.27	8.86	64.68	47,246	30,559	2,708	51,220	33,129	2,939
Honduras	L. Brande	164	22	7	11.67	2.03	2.22	69.00	8.06	66.59	46,421	27,912	2,250	51,840	34,510	2,782
Sugar Cane	C. E. Miller	99	8	6	8.84	2.37	2.32	65.39	5.79	64.60	13,839	8,940	518	17,280	11,163	649

General Results of Analyses Bearing upon the Question of Available Sugar.

By reference to the table giving the general results of all the analyses of the several varieties of sorghum, in 1879, 1880, and 1881, the aggregate number of analyses being 4,042, and the varieties analyzed being about 40, these results having been obtained from as many varieties by so large a number of separate analyses made in successive years, the general conclusion reached appears established beyond question.

During the early stages of devolopment of these plants, up to and including the sixth stage, the available sugar is given as a minus quantity, *i. e.*, the amount of sucrose in the juice is less than the sum of the glucose and other solids. Also, in the seventh stage, the available sugar is practically none, being only .13 per cent, and this stage represents the period when the seed is in the milky state. It is, then, obviously absurd to expect to obtain any sugar by working up the crop until it has advanced beyond this condition toward maturity.

It will also be observed in the table, that, during these early stages, the amount of this minus available sugar remains nearly the same, the average for the first five stages being — 3.22 per cent; and also, that the available sugar, after it first appears, rapidly increases in quantity, and remains practically constant through the several subsequent stages; and in this it agrees, as will be seen, with the development of the sucrose, which, at a certain period, is very rapid, and afterward nearly constant through the season, while, as has been remarked, the sum of the glucose and solids is nearly the same throughout.

In the table, is given the average of the determinations for each stage of development for all varieties.

In addition to the columns giving the average results of the several determinations given for each variety, there is given a column showing what is termed the percentage of available sugar present in the juice, *i. e.*, the amount of sugar which may be obtained as sugar from the juice, for, as is known, the amount of sugar to be obtained from any specimen of juice, depends obviously upon the amount of sugar present; and not alone upon this, but also upon the amount of glucose, and other matters present, since, as is well known, the effect of these is to prevent the crystallization of a portion of the sugar present, and, hence, to increase the relative amount of molasses, the molasses consisting of glucose, water, mineral matters (the ash), and more or less sugar, which practically can not be recovered as such. Now, this molasses producing (melassigenic) property of the several impurities present in the juices of cane, sorghum, and beets, has been a subject of con-

siderable experiment, but at the present time the exact effect of each impurity is not known.

The average of thirty-four analyses of sorghum juices, made in this laboratory, shows an average percentage of ash equal to 1.06; the maximum being 1.66 per cent, and the minimum being .82 per cent. We may, then, safely estimate the ash as being about one per cent of the juice.

Now, while all authorities are agreed as to the melassigenic effect of certain of the mineral constituents of the ash, there is much difference as to the action of other mineral matters; and while some of these are regarded as quite indifferent in their action, other constituents of the ash are shown to strongly favor the crystallization of the sugar. For example, potassium carbonate increases the quantity of molasses produced, potassium sulphate appears to have no effect, while magnesium sulphate seems to favor the crystallization of sugar, and thus decrease the amount of molasses.

It is highly probable, that much of the good effect attributed to the use of sulphurous acid, as an aid in the crystallization of syrups, is due to the fact, that it converts the harmful alkaline carbonates into the inert sulphates. In the reports of my work, I, in accordance with a common practice among sugar makers, made use of the so-called "exponent," which represented the relative purity of the different juices. This "exponent" was the percentage of sucrose in the total solids of the juice; and this represented the percentage of the sugar present in the juice, which could be in practice obtained as sugar. While this method of calculation is doubtless, at least approximately, correct, when applied to those juices which are generally worked up for sugar, it is obviously erroneous when applied to juices poor in sugar, and with comparatively large amounts of other solids.

I have, therefore, adopted a method for calculating the available sugar, viz.:—the difference between the per cent of sucrose and the sum of the per cents of glucose and solids not sugar, and although confident that all the experiments of Marschall, La Grange, and others, go to prove that the amount of available sugar thus shown is beyond question too low, it is at least safe to err upon this side rather than the other.

If we apply these two methods to two specimens of juice, one good and the other poor, it will be seen that for the good juice, the two methods approximately agree, while for the poor juice, they differ widely, and there is no doubt but that the method of the exponent is in such a case inapplicable; *e. g.*:

Juice A contains, sucrose, 3.51 per cent; glucose, 4.50 per cent; solids, 1.78 per cent. The exponent would be 35.85, and the available

sugar 1.26 per cent; or, by the other method, 3.51—(4.50+1.78)= —2.77.

Juice B contains, sucrose, 15.30 per cent; glucose, .87 per cent; solids, 2.95 per cent. The exponent would be 80.02, and the available sugar, 12.24 per cent; or, by the other method, 15.30—(.87+2.95)= 11.48 per cent.

It is from the above assumed cases obvious, that the last method of calculation, although giving probably too low a result, is one of general application, since no one would regard it as possible practically to obtain any sugar from a juice having the composition of the one marked A.

It will be seen from the tables, that the available sugar begins to show itself quite late in the development of the plant, generally about the seventh or eighth stage, and it is obvious that, previous to this period, the available sugar exists, as we may say, as a minus quantity; but owing to the practical importance of this matter, its discussion will be again taken up.

Danger of mixing Immature with Mature Cane in Working.

It is of greatest practical importance, also, to consider the effect of mixing immature with mature canes in the working. If, for example, a ton of sorghum in the tenth stage was mixed with an equal quantity in the third stage, and the mixed juices together boiled to a syrup, it is doubtful whether any sugar would be obtained, for, as will be seen, the first lot would yield a juice having 4.49 per cent of available sugar, the second lot of juice would have —3.24 per cent, and the mixed juice would, of course, have but .62 per cent available—so small a quantity as to be practically valueless. It is, then, to be remembered, that, for the purpose of sugar making, every unripe cane allowed to go to the mill is not only worthless in itself, but far *worse than worthless*, since it causes the loss of sugar otherwise available.

This fact will more clearly appear, if the necessary calculations are given of the results. Supposing that the mill gives 60 per cent of the weight of stalks in juice: we should then have 1,200 pounds of juice from each ton of stalks, and the former would give 4.49 per cent of sugar, or 53.88 pounds, while the latter would give —3.24, or minus 38.88 pounds, the difference being 15 pounds of sugar from the two tons of stalks, equal to .625 per cent of 2,400 pounds of juice.

We thus see that, by mixing in the immature canes, we really obtain only about one-fourth the sugar which the one ton of good cane would have yielded alone.

The above facts are practically understood by the sugar planters of

Cuba and Louisiana, for they are careful to cut off and leave upon the field the upper and immature portion of the sugar-cane, knowing by experience that, by sending it to the mill, it results in actual loss in their product of sugar.

That their practice is entirely justified by the results of analysis, will be seen by reference to the table below, which represents the average results in each case of four analyses of the juices from the butt, the middle, and the top, of three varieties of sugar-cane grown in Louisiana.

TABLE SHOWING RELATIVE VALUE OF DIFFERENT PARTS OF SUGAR-CANE STALK.

	Butt.	Middle.	Top.
Sucrose.......Per cent..	15.36	12.95	3.21
Glucose....... " ..	.75	1.42	3.68
Solids....... " ..	.24	.68	2.23
Available sugar....... " ..	14.37	10.85	—2.70
Specific gravity.......	1.068	1.061	1.038

From the above results, there would seem to be, in the immature sugar-cane top, a close resemblance to the immature stalk of sorghum, and yet the analogy ceases so soon as the sorghums have attained full maturity; for, as the results of very many analyses show, there is practically no difference in the juice from the upper or lower half of the sorghum stalks.

This difference is probably due to the fact that, owing to the short season, comparatively, it is impossible for the sugar-cane to reach, even in Louisiana, a condition of full maturity.

The Increase in Sugar during the later Stages in the Development of the Sorghum is not the Result of a Loss of Water or Drying Up of the Plant.

This is a matter of such great practical importance to the manufacturer of sugar from the sorghums, that a fuller discussion of the facts obtained by analysis is justified, since, if it were true that the absolute amount of sugar present in the plant was at its maximum during the early stages in its development, it would certainly be advisable that the crop be worked at such time as showed the greatest per cent of juice, since, obviously, a larger per cent of the sugar actually present in the plant would be extracted by pressing the cane at such time as showed the maximum per cent of juice.

It is true, as will be seen, that the per cent of juice expressed by the mill is greatest in the earlier stages of development; and it is also true

that the actual amount of water present in the plant, and in the expressed juice, is less at the later stages in the plant's life.

But it is obvious that, if the increased per cent of sugar, as shown in the juice at these later stages, was due simply to loss of water through a drying up of the plant, then it would necessarily follow that, by such evaporation, the relative percentages of the several constituents present in the juice would be maintained; but such is far from being the case, as will be seen by the following table; for, while the sugar and the solids not sugar increase, it will be seen that their increase is by no means proportional, the sucrose increasing from the first to the seventeenth stage 688 per cent, while the solids increase only 135 per cent; besides, glucose, instead of increasing, as would be natural and inevitable, if we regard the matter as simply one of loss of water by evaporation, decreases 65 per cent.

But it is obvious that, if the water present in the juice at the different stages be multiplied by the per cent of the several constituents, as, *e. g.*, sucrose, the series of products would necessarily be a constant quantity; but, on the other hand, we find that the sucrose increases 606 per cent, the solids 111 per cent, while the glucose *decreases* 68 per cent. Such a result is wholly at variance with the view, that the increase of sugar is only apparent and due to the evaporation of water.

It will be observed that the actual increase in sugar in the plant is in reality greater than is shown in the above results, since it is obvious that a larger proportion of that present in the plant is expressed at the time when the amount of water is at its maximum, viz., during the earlier stages, and that a larger proportion is left in the bagasse during the later stages.

TABLE SHOWING THAT THE INCREASE IN SUGAR DURING THE LATER STAGES IS NOT DUE TO A DRYING UP OF THE PLANT.

Stages.	Per cent of solids.	Per cent of juice.	Per cent of water.	No. of analyses.	Per cent of sucrose.	Per cent of glucose.	Per cent of solids.	Water × sucrose.	Water × glucose.	Water × solids.
1.	7.73	58.72	54.18	59	1.74	4.26	1.73	943	2.307	.937
2.	9.23	59.52	54 03	70	2 93	4 44	1.86	1 583	2 399	1 005
3.	9.71	59 58	53 79	58	3 47	4.45	1.79	1 867	2.394	.963
4.	10.49	61.58	55.12	72	4 29	4.28	1.92	2.365	2 359	1 058
5.	11.14	63 00	55 98	77	5.06	4.11	1 97	2 834	2.302	1.103
6.	12.79	62.60	54 59	64	6.40	3 91	2 45	3 494	2.151	1 337
7.	13.43	63 84	55.27	70	7.38	3.86	2 19	4 079	2 133	1.210
8.	13.89	65.65	56.53	111	7 69	3.83	2.37	4 347	2.165	1.340
9.	14 56	64 96	55.50	266	8.95	3.19	2.42	4 967	1.770	1.343
10.	15.08	64.94	55.15	217	9.98	2 60	2 50	5.507	1.434	1.379
11.	15.73	65 04	54 81	166	10 66	2 35	2.72	5.970	1.105	1.511
12.	16.08	63.62	53.39	170	11.18	2 07	2.83	5.912	1.095	1.497
13.	16.25	63.14	52 88	183	11 40	2.03	2.82	5.868	1.045	1.451
14.	16 60	61.72	51.47	191	11 76	1 88	2.96	6 053	.968	1.524
15.	16.65	60.45	50.39	217	11.69	1 81	3.15	5.891	.912	1.587
16.	17 36	61 20	50 58	339	12.40	1.64	3.32	6.272	.830	1 679
17.	19 35	60 17	48 53	197	13.72	1 56	4 07	6.658	.757	1.975
18.	17.19	62.09	51 42	191	11.92	1.85	3.42	6.129	.951	1.759

During the examinations of the various sorghums, the amount of sucrose found present in many of the juices, especially during the later periods of the plant's life, and determined both by analysis and polarization, was exceptionally high:

5 Analyses gave between 19 and 20 per cent of sugar averaging 19.35.
23 Analyses gave between 18 and 19 per cent of sugar averaging 18.35.
46 Analyses gave between 17 and 18 per cent of sugar averaging 17.66.
73 Analyses gave between 16 and 17 per cent of sugar averaging 16.48.

The average amount of juice expressed was as follows:

	Per cent.
In the 5 analyses	57.33
In the 23 analyses	57.72
In the 46 analyses	57.82
In the 73 analyses	57.92

In these cases certainly we might look for such drying up as is insisted upon by many, but we have here an average increase from 16.48 per cent of sucrose to 19.35 per cent, or 2.87 per cent, while the loss in juice is, on the average, from 57.92 per cent to 57.33 per cent, or only .59 of one per cent. Besides, if we compare the results, as given in the preceeding table, we find that the average of juice expressed from the stalks in 59 analyses, in the first stage, *i. e.*, before even the plant had headed out, and when it might naturally be expected to be exceptionally full of juice, was but 58.72 per cent, practically the same as the amount expressed when the sugar present was exceptionally high. But it is to be observed, that, since the average sucrose, at this first

stage, was but 1.74 per cent, the percentage of juice expressed being the same as when from 16 to 20 per cent of sucrose was present, it necessarily follows that the amount of water present in the plant must have been much greater early in the plant's life than at the close; but there is no reason to suppose that this decrease in water is in the nature of evaporation, or a drying up of the plant.

Why it is I do not know. It is an interesting point for further investigation. It would seem, if I might reason upon it, as though when the plant was endeavoring to provide for this elaboration of the seed in the plant, it was natural for it to elaborate these constituents which were necessary for the building up of the seed; but its organs by which these were elaborated were stimulated to an excess, and they had acquired, if you will say so, a sort of momentum, so that, after the demand was supplied, which the seed made, there still went on an elaboration of these constituents in the plant. Whether that is the explanation or not, as a matter of fact, the sugar increases in the plant after the seed is thoroughly ripe, and will actually shell out. And the same has been found true of corn.

Analyses of Fresh and Dry Juices.

In the following table is given the analyses of thirteen juices in their condition as freshly expressed, and after they had been rapidly dried in a warm chamber.

It was intended to make a more thorough examination of these dried juices to determine the character of the several constituents present besides the sugars, viz., the organic substances which are to be removed, if at all, by defecation, and the mineral constituents of the ash.

Excluding the analyses of the juices from suckers and leaves of Nos. 7 and 8, as being hardly comparable with the others, the average analysis of the fresh juices is as follows:

Per cent of juice expressed	56.62
Specific gravity	1.0702
Per cent glucose in juice	1.17
Per cent sucrose in juice	12.36
Per cent solids not sugar in juice	3.08
Per cent of polarization	12.16
Per cent of water in juice	85.52
Per cent of dry matter in juice	14.47

It will be observed that there was lost by drying 85.52 per cent, and the solids remaining were 14.47 per cent; but, as will be seen by the analyses of the fresh juices, there was an average of 16.61 per cent of total solids: this shows that, in the operation of drying, there was a loss of 2.14 per cent, equal to 12.88 per cent of the total solids.

The average proximate analyses of the dried juices gave:

	Per cent.
Ether extract	0.82
Alcohol extract	70.15
Water extract	8.23
Insoluble	20.80
	100.00

	Per cent.
Albuminoids (nitrogen + 6.25)	6.37
Ash	5.87
Sucrose	39.96
Glucose	12.32
Water	3.06
Undetermined	32.42
	100.00

The ether extract contains free organic acids, chlorophyl, fixed oils, fats and waxes, volatile oils, but no mineral matter.

The alcohol extract contains mineral matter, nitrates, organic acids and their salts, glucosides, coloring matter, sugars, albuminoids, and non-albuminoids, nitrogenous matter, amides, etc.

The water extract contains soluble albuminoids, gum, pectin matter, dextrinoid bodies, and coloring matter.

The insoluble matter consists of crude fiber and mineral matter, silica, etc.

Now, it will be seen that there was present in the total solids of the fresh juices 81.46 per cent of the two sugars, but in the total solids of the dried juices there was only 52.28 per cent of the two sugars. Also, there was in total sugars of the fresh juices 91.35 per cent of sucrose and 8.65 per cent of glucose; but in the total sugars of the dried juices there was only 76.44 per cent of sucrose and 23.56 per cent of glucose.

The above results are important, as showing how liable the juice is to undergo fermentation, and loss of sugar, during evaporation even, unless, by means of defecation, certain impurities be removed; and, although many farmers still persist in the manufacture of syrup, "without chemicals," as they say, by simply boiling down the freshly expressed juice, removing only such impurities as may be brought to the surface as scum during the evaporation, it is altogether likely that they have a loss of sugar greater than would occur in the sediment and scum of a good defecation, besides producing a syrup which is likely to have poor keeping qualities, owing to its tendency to ferment upon the approach of warm weather.

The analyses of the suckers (No. 7), and of the leaves from the suckers (No. 8), are interesting, and of practical value.

These suckers were those that had sprung up from the roots of those stalks which had been previously cut up for analyses; and it will be observed how low is the content of sugar, and how great the percentage of ash, in their juices. The large percentage of nitrogen is also noticeable, as also the ether extracts of the leaves, owing to an excess

of chlorophyl in the leaf juice. The worthlessness, therefore, of immature suckers, for the purpose of sugar production, is obvious; and also the importance of stripping the cane, in order to secure the best results in sugar, is manifest. In another place, this matter is considered at greater length.

ANALYSES OF FRESH AND DRIED JUICES.

Fresh Juices.

Date.	Variety.	Number of analyses of fresh juices.	Per cent of juice.	Specific gravity.	Per cent of glucose.	Per cent of sucrose.	Per cent of solids not sugar.
Sept. 14	New variety (H. S. Coll)	1	62.27	1 068	1.15	11 79	3 26
14	White Liberian (Nesbit)	2	60.32	1.072	.93	13 31	3.28
21	New variety (H. S. Coll)	3	54.09	1.061	1.06	12 18	1 57
21	White Liberian (Nesbit)	4	62.35	1.074	.98	13 83	2 65
23	.... do.	5	56.82	1 068	.88	12 04	3 28
23	New variety (H. S. Coll)	6	60.15	1 063	1.05	10.79	3 34
Oct. 3	Suckers from rows 2, 3, 4, 5	7	62.02	1 022	2.04	.66	2 53
3	Leaves from rows 2, 3, 4, 5	8	37.03	1.025	1.40	.27	4.45
10	Neeazana	9	57 55	1.075	1.75	13 00	3.79
11	Link's hybrid	10	61 31	1 074	.69	14.27	2.71
12	White Liberian (Nesbit)	11	57 89	1 068	.94	11 81	3 07
13	White Liberian (Learning)	12	58 86	1.070	.72	12 14	3 68
16	Ta-Min-Hung-Liang	13	48.58	1 054	.58	7 94	3 69
Dec. 8	New variety (R. Haswell)	14	39 25	1.095	3.34	15 17	2 61
	Average	....	56.62	1 0702	1.17	12.36	3 08

Date.	Variety.	Polarization.	Per cent of begasse.	Weight of juice.	Weight of dry juice.	Per cent of water in juice.	Per cent of dry juice.
Sept. 14	New variety (H. S. Coll)	12.06	37.73	3106	468	84.93	15 07
14	White Liberian (Nesbit)	13.60	39.68	2532	410	83.81	16.19
21	New variety (H. S. Coll)	11 16	45 91	2825	437	84 53	15 47
21	White Liberian (Nesbit)	13 65	37 65	2860	505	82 34	17.66
23	..... do.	12 35	43 18	3494	417	88 06	11 94
23	New variety (H. S. Coll)	10.61	39 85	3964	407	89 73	10.27
Oct. 3	Suckers from rows 2, 3. 4, 5	1 31	37.98	2541	136	94 65	5.35
3	Leaves from rows 2, 3, 4, 5	—.98	62.97	571	45	92 12	7.88
10	Neeazana	13.27	42 45	3203	439	86 29	13.71
11	Link's hybrid	14 21	38.69	4668	525	88 75	11 25
12	White Liberian (Nesbit)	11.38	42.11	2878	420	85 41	14.59
13	White Liberian (Learning)	12.49	41.14	2765	339	87.74	12.26
16	Ta-Min-Hung-Liang	7.45	51 42	....	479		
Dec. 8	New variety (R. Haswell)	13.72	60.75	1449	302	79.18	20.82
	Average	12.16	43.38	.....	......	85.52	14.47

Dried Juices.

Date.	Variety.	Number of analyses of dry juice.	Remarks.	Ether extract.	Alcohol extract.	Water extract.	Insoluble residue.
Sept. 14	New variety (H. S. Coll)	1	....	.40	72.52	12.42	14 66
14	White Liberian (Nesbit)	2	....	.42	60.35	5.67	33.56
21	New variety (H. S. Coll)	3	....	.87	80.53	3.29	15.31
21	White Liberian (Nesbit)	4	....	.40	81 55	3 07	14.98
23	..... do.	5	....	.69	72.64	7.01	19.66
23	New variety (H. S. Coll)	6	Fermented	.79	67.06	10.46	21.69
Oct. 3	Suckers from rows 2, 3, 4, 5	7	....	.70	62.13	12 85	24.32
3	Leaves from rows 2, 3, 4, 5	8	....	7.19	47 85	12 02	32.94
10	Neeazana	9	....	.67	73 73	13 75	11.85
11	Link's hybrid	10	....	1.54	62.12	3.57	32.77
12	White Liberian (Nesbit)	11	....	2 22	56.75	20 63	20 40
13	White Liberian (Leaming)	12	....	.52	81.15	4 08	14.25
16	Ta-Min-Hung-Liang.	13	Fermented	Lost.	...	..	
Dec. 8	New variety (R. Haswell)	14	....	.47	63.24	6 60	29 69
	Average	....	....	.817	70.15	8.23	20.80

Date.	Variety.	Nitrogen multiplied by 6.25.	Glucose.	Sucrose.	Ash in alcohol extract.	Total ash.	Moisture.
Sept. 14	New variety (H. S. Coll)	5.750	9 866	43.193	3 68	5 80	1 90
14	White Liberian (Nesbit)	5 625	8 533	52.186	3 31	5 45	2 40
21	New variety (H. S. Coll)	5.625	13.666	48 703	4 38	5 65	3 65
21	White Liberian (Nesbit)	5.625	8 533	56 873	2 62	4 50	6.30
23	..... do.	5.750	11.000	39 330	3 96	7 15	2.10
23	New variety (H. S. Coll)	5.938	9.000	32 110	4 60	7 85	2.40
Oct. 3	Suckers from rows 2, 3, 4, 5	15 938	...	.. .	12 34	7.30	6 25
3	Leaves from rows 2, 3, 4, 5	21.000		.	10.08	8 20	3.80
10	Neeazana	3.688	18 933	30 780	5.14	4 65	2 60
11	Link's hybrid	9.250	22 133	16.973	4.61	5.60	2.75
12	White Liberian (Nesbit)	7 188	14 066	22 736	3 19	6 35	2.65
13	White Liberian (Leaming)	8.250	8.333	46.550	4.51	5.85	2 35
16	Ta-Min-Hung-Liang.	....			..	.	...
Dec. 8	New variety (R. Haswell)	7 375	11 400	50 096	4.44	5.70	4.80
	Average	6.369	12 315	39.656	4.04	5.87	3.06

COMPARATIVE VALUE OF DIFFERENT PARTS OF THE STALK OF SORGHUM FOR SUGAR.

In 1879, there were made a large number of analyses of the juices of four varieties of sorghum, for the purpose of determining the relative value of the upper and lower halves of the cane for the production of syrup and sugar. The canes were, in each case, about equally divided by weight into upper and lower halves. The results obtained were as follows:

EARLY AMBER.

Date.	Development.	Number of stalks used for analysis.	Height of entire stalk, in feet.	Height of top, in feet.	Height of butt, in feet.	Diameter of butt, in feet.	Weight of entire stalk, in pounds.	Weight of stripped stalk, in pounds.	Weight of top.	Weight of butt.	Per cent of water in top.	Per cent of water in butt.	Average per cent of water in cane.	Weight of juice in top.	Weight of juice in butt.	Total weight of juice.	Per cent of juice in entire cane.	Specific gravity of juice from tops.
July 18	Flower stalks just out; compact	2	6	4.3	2.4	....	3 32	2.64	....	...	82.39	83.00	82.70	.58	.57	1.15	34.6	1.046
July 26	Flower stalks begun to spread	2	8 2	5 7	2.5	..	2 74	.	....	..	75.35	51 03	63 19	.49	59	1.08	39 6	1 064
Aug. 7	Flower stalks spreading; seed milky	2	5 1	2.8	2 3	.075	2 80	1 10	..	...	74.94	78.63	76 79	.46	59	1.05	37.2	1.071
Aug. 11	Seed browning; harder	2	5 4	2 9	2.5	075	2 80	2 12	...	....	71.06	76 48	73.77	.47	.59	1 06	37 9	1.078
Aug. 13	Seed harder; stalk suckering	2	5 2	2 9	2.3	.063	3 14	2 12	....	...	70.70	69 62	70.16	.45	55	1.00	31 9	1.082
Aug. 16	do.	2	6.4	.	..	.075	3 64	2.30	...	..	89.96	72.17	80.07	.90	.69	1.59	32 7	1 081
Aug. 20	Seed nearly dry, but crushable	2	5.8	3.3	2 5	068	3 02	2 14	....	..	....	.....	....	.46	.57	1.03	32 8	1 081
Aug. 22	Seed hard, but splitable	2	5.6	3.1	2 5	075	3 52	2.48	....	....	....	.....	....	50	.60	1 10	31.3	1.077
Aug. 26	do.	2	5 2	3.1	2.1	083	4 52	2 84	....	....	..	71.97	...	.65	.76	1.41	26.9	1 081
Aug. 30	Core of cane turning red	2	5 3	...	....	075	2 52	2.18	....	...	67.38	74.17	70.78	..		....	..	1.085
Sept. 8	Ripe; seed dry and mostly gone	2	5 1	2 9	2.2	070	3 63	2.02	.	..	67.07	70 89	68 98	.388	.567	.955	26.2	1.087
Sept. 12	Ripe; seed carried away entirely	2	5 5	3.3	2.2	.06	3 56	1 79	89	.99	68 47	76 48	72.47	344	.379	.723	20.3	1 080
Sept. 12	Ripe and dry; carried away by birds	2	5.1	3.2	1.9	.08	3.77	2.02	1 01	1.01	71 61	71.45	71.53	.425	.493	.918	24.3	1.081
Sept. 16	Ripe and dry	2	5 5	3.4	2.1	.08	4 47	1 60	.90	.70	71 60	74.80	73.20	.487	.540	1.027	22.9	1 081
Sept. 22	do	5	5 2	.	...	.075	8.80	3.80		....	...	....	76.75	..	....	1.775	20.0	....
Oct. 3	do	2	5.5	3.4	2 1	.09	4.11	2.04	1 03	1 01	67.75	.69.17	68.46	.467	.419	.886	21.5	1.076
Oct. 13	do	2	5 9	3 8	2.1	.07	3 77	1 75	.87	88	68.47	70.94	69.70	.434	.406	.840	22 2	1.082
Oct. 20	do	2	5 7	3 4	2.3	.07	3.75	1 76	.82	.94	68 34	65.15	66.74	.337	.434	.771	21.2	1 085
Oct. 29	Leaves killed by frost	2	5.1	3.1	2.0	.09	3 03	1.80	.87	.93	68.31	70.45	69.38	.469	.540	1 009	33.3	1 092
Nov. 8	Quite dead	2	5.9	3.7	2.2	.06	2.54	1.76	.83	.93	69.98	71.83	70.90	.318	.494	.812	31.9	1.084
	Foreign.																	
Sept. 11	Brown husks full of milk (D. Smith)	2	6	....	....	.082	1.75	1.32	....	....	......	.....	72.36	....	....	.513	29.2	.....
Sept. 13	Just browning (Hutchinson)	2	6	3.7	2.3	.062	2 24	2.01	1.02	.99	78.95	84 82	81.88	.566	.538	1.094	48.8	..039
Sept. 17	Between milk and dough (D. Smith)	2	6.2	3.8	2.4	.062	1.72	1.27	.67	.60	73.79	72.93	73.36	.295	.317	.612	35.6	1.076
Sept. 13	In dough (Hutchinson)	2	6	3.6	2.4	.062	2.10	1.50	.74	76	75.83	68.27	72.05	.373	.377	.750	35.6	1.073

EARLY AMBER.

Date.	Development.	Specific gravity of juice from butts.	Average specific gravity of juice.	Per cent of solids in juice from tops.	Per cent of solids in juice from butts.	Per cent of glucose in juice from tops.	Per cent of glucose in juice from butts.	Per cent of sucrose in juice from tops.	Per cent of sucrose in juice from butts.	Average per cent of glucose.	Average per cent of sucrose.	Solids (not sugar) in juice from tops.	Solids (not sugar) in juice from butts.	Average solids, not sugar.	Per cent of sucrose in tops by polarization.	Per cent of sucrose in butts by polarization.	Average per cent of sucrose by polarization.
July 18	Flower stalks just out; compact..	1.048	1.047	10.28	10.81	4.7	2.9	4.2	4.7	3.77	4.43	1.43	3.27	2.35	....	....	....
July 26	Flower stalks begun to spread	1.064	1.064	14.13	13.07	3.9	2.4	7.8	8.0	3.14	7.85	2.44	2.71	2.53	.	...	....
Aug. 7	Flower stalks spreading; seed milky	1.070	1.070	15.85	13.57	3.4	2.6	11.1	11.2	2.97	11.15	1.42	1.77	1.56	...	...	....
Aug. 11	Seed browning; harder	1.080	1.079	17.62	17.50	3.0	1.7	13.6	14.0	2.66	13.78	1.06	1.80	1.43	...	...	....
Aug. 13	Seed harder; Stalk puckering	1.082	1.082	17.52	16.63	1.9	1.6	14.2	14.3	1.74	14.25	1.49	.75	1.12	...	..	....
Aug. 16	........do	1.080	1.080	17.62	16.80	1.6	1.5	15.1	14.3	1.54	14.67	.91	1.09	1.00	...	..	....
Aug. 20	Seed nearly dry, but crushable	1.081	1.081	18.13	18.13	1.9	1.3	14.2	14.0	1.60	14.13	2.05	...	3.25	...	..	...
Aug. 22	Seed hard, but splitable	1.074	1.075	...	....	1.5	1.5	15.0	14.6	1.48	14.78	....	...	...	...	..	....
Aug. 26	....do	1.078	1.079	....	16.12	1.3	1.3	14.6	14.3	1.31	14.45	... .	.52	.	...		....
Aug. 30	Core of cane turning red	1.074	1.079	19.89	17.23	1.2	1.5	14.8	14.7	1.33	14.72	3.92	1.02	2.47	..	....	....
Sept. 8	Ripe; seed dry and mostly gone	1.075	1.081	20.50	17.35	.6	.8	9.4	7.5	.7	8.45	10.50	9.05	9.77	....	....	....
Sept. 12	Ripe; seed carried away entirely	1.070	1.075	18.47	16.79	.6	.6	14.8	14.7	.6	14.75	3.07	1.49	2.28	...	..	....
Sept. 12	Ripe and dry; carried away by birds	1.079	1.080	18.91	18.36	.7	.7	14.5	14.3	.7	14.4	3.71	3.36	3.53	....	..	....
Sept. 16	Ripe and dry	1.079	1.080	18.82	18.70	.5	.8	16.1	15.8	.65	15.95	2.22	2.10	2.16	...	..	....
Sept. 22	........do		1.079	17.67		.73	.75	14.9	14.7	.7	14.8	2.07	.	2.27	.	...	....
Oct. 3	........do	1.070	1.073	18.63	17.27	.9	1.3	14.7	14.1	1.1	14.4	3.03	1.87	2.45	13.8		....
Oct. 13	........do	1.080	1.081	..	18.93	.7	.7	15.9	15.7	.7	15.8	...	2.49	.	15.1	15.1	15.1
Oct. 20	.. ....do	1.083	1.084	20.89	20.75	1.0	.9	16.0	15.5	.95	15.75	3.89	4.35	4.12	15.1	15.2	15.15
Oct. 29	Leaves killed by frost	1.084	1.088	21.69	20.76	.9	1.4	17.7	16.3	1.1	17.0	3.09	3.06	3.08	....	...	....
Nov. 8	Quite dead	1.073	1.078	19.87	17.57	4.1	4.5	11.9	10.0	4.3	10.9	3.87	3.07	3.47	....	....	....
	Foreign.																
Sept. 11	Brown husks full of milk (D. Smith)	.....	1.078	19.36		3.2	..	....	.	3.2	12.1	......	....	4.06	....	...	....
Sept. 13	Just browning (Hutchinson)	1.031	1.035	9.20	8.40	3.7	3.4	4.6	2.4	3.5	3.5	.90	2.60	1.70	....	...	....
Sept. 17	Between hull and dough (D. Smith)	1.070	1.073	18.54	17.30	2.9	3.8	12.2	12.3	3.35	12.25	3.44	1.20	2.32	....	.	....
Sept. 13	In dough (Hutchinson)	1.071	1.072	18.37	17.76	2.1	3.6	12.3	8.8	2.85	10.55	3.97	5.36	4.66	...	....	....

WHITE LIBERIAN.

Date.		Development.	Number of stalks used for analysis.	Length of stalk, in feet.	Length of top, in feet.	Length of butt, in feet.	Diameter at butt, in feet	Weight of stalk in pounds.	Weight of stalk stripped	Weight of top, in pounds.	Weight of butt, in pounds.	Per cent of water in top.	Per cent of water in butt.	Average per cent water in cane.	Weight of juice from tops.	Weight of juice from butts.	Total weight of juice, in pounds.	Per cent of juice in entire cane.	Specific gravity of juice from tops.
July	18	Flower-stalk just out and compact	2	6.1	3.5	2.6	....	3.28	2.62	...	...	83.79	83.31	83.55	.60	.59	1.19	36.4	1.046
	26	Flower-stalk spreading; seed milky	2	8.2	5.7	2.5	088	2.64	2.52	..	....	79.71	78.93	79.32	.49	.60	1.09	38.5	1.043
Aug.	7	Flower-stalk more spreading; seed milky	2	5.4	2.5	2.9	...	2.76	2.52	...	...	75.75	78.36	77.06	.45	.71	1.16	...	1.061
	11	Seed browning; harder	2	5.8	3.0	2.8	.	3.42	2.66	...	....	72.79	76.36	74.58	.48	62	1.10	31.7	1.079
	13	Seed harder	2	5.8	3.6	2.2	.063	3.52	2.58	..	..	70.98	75.73	73.36	.66	70	1.36	39.2	1.081
	16	Juice brown in color	2	8.0	5.7	2.3	.075	3.80	2.40	..	....	71.96	72.00	71.98	.59	62	1.21	31.0	1.087
	20	Seed as before	2	8.2	5.7	2.5	075	3.98	2.34	...	...	69.77	73.31	71.54	.50	.65	1.15	28.9	1.085
	22	Seed almost dry	2	5.5	....	..	...	4.14	2.62	....	....	. ..	75.91	.....	.59	.62	1.21	29.2	1.083
	26	......do	2	5.3	3.1	2.2	.078	4.16	2.44	....	..	69.37	.....	.....	.58	.64	1.22	29.5	1.085
	30	Butt turned red at center	2	4.9	2.6	2.3	.075	3.76	.	...	...	70.21	72.47	71.34	.	.	......	. . .	1.080
Sept.	8	Ripe; seed dry	1	6.5	3.9	2.6	.072	2.10	1.26	.	..	70.30	71.42	70.86	.289	295	.584	27.8	1.083
	13	Ripe; seed carried off by birds	2	5.5	2.75	2.25	.062	4.18	2.12	1.12	1.00	70.30	85.06	77.68	.453	.437	.890	21.3	1.082
	15	Ripe and dry	2	5.5	2.75	2.25	.062	4.04	2.01	1.02	99	70.98	71.84	71.41	.494	.399	.893	22.1	1.081
	20	.......do	2	5.2	3.20	2.0	.088	3.66	2.19	1.13	1.06	75.00	75.56	75.28	.542	.556	1.098	21.1	1.078
	27	Ripe and dry; largely suckered	2	6.07	3.71	2.36	.088	4.59	2.32	1.17	1.15	70.00	72.01	71.00	.445	529	.974	21.2	1.074
Oct.	3	......do	2	5.08	2.95	2.13	075	3.20	1.81	.92	.89	71.72	76.10	73.91	.423	.426	.849	26.6	1.078
	13	Ripe and dry; juices bright red	2	5.08	3.05	2.03	072	3.33	1.61	.82	79	69.22	71.68	70.45	.388	.362	.750	22.5	1.080
	21	Juices bright red	2	5.74	3.38	2.36	.072	3.36	1.84	.97	.97	65.65	80.49	73.07	.346	.406	.752	22.6	1.068
	29	Leaves killed by frost	2	5.08	3.05	2.03	.069	2.49	1.57	.78	.79	67.24	72.08	69.66	.344	.375	.719	28.8	1.082
Nov.	8	Quite dead	2	4.43	2.46	1.97	.079	2.18	1.21	.58	.63	69.89	71.46	70.17	.322	.323	.646	29.6	1.084
		Foreign.																	
Sept.	17	Seed just brown; not in milk	1	7.20	4.54	2.66	.083	2.67	2.10	1.01	1.09	74.93	78.41	76.67	461	.428	.889	33.2	1.055
Oct.	1	Browning, but not much milk	2	6.63	4.17	2.46	085	2.77	2.26	1.14	1.12	72.64	71.54	72.09	.426	461	.887	32.0	1.070
	8	Brown and in milk	2	7.54	4.75	2.79	.092	4.01	3.12	1.44	1.68	74.73	75.06	74.89	662	.792	1.454	36.2	1.074
	24	Brown and hard	2	7.54	4.69	2.85	.075	3.45	2.71	1.34	1.87	61.47	71.02	66.24	.423	.527	.950	27.5	1.088

WHITE LIBERIAN.

Date.	Development.	Specific gravity of juice from butts.	Average specific gravity of juice.	Per cent solids in juice from tops.	Per cent solids in juice from butts.	Per cent of glucose in juice from tops.	Per cent of glucose in juice from butts.	Per cent of sucrose in juice from tops.	Per cent of sucrose in juice from butts.	Average per cent glucose in juice.	Average per cent sucrose in juice.	Solids not sugar in juice from tops.	Solids not sugar in juice from butts.	Solids not sugar, average.	Per cent of sucrose by polariscope in juice of tops.	Per cent of sucrose by polariscope in juice of butts.	Average per cent polariscope.
July 18	Flower stalk just out and compact	1.048	1.047	9.87	10.73	5.2	3.0	4.6	6.9	4.1	5.7	.09	.83	.46	....	....	....
July 26	Flower stalk spreading; seed milky	1.048	1.046	8.97	10.10	4.2	2.9	4.1	5.3	3.5	4.7	.72	1.87	1.30	....	....	....
Aug. 7	Flower stalk more spreading; seed milky	1.066	1.064	14.76	14.53	3.6	2.8	10.0	11.9	3.2	11.0	1.14	....	....	....	....	....
Aug. 11	Seed browning; harder	1.077	1.078	17.66	17.14	2.8	1.9	13.4	12.4	2.4	12.9	1.49	2.78	2.14	....	....	....
Aug. 13	Seed harder	1.081	1.081	17.45	17.65	2.2	1.7	13.4	14.2	2.0	13.8	1.78	1.75	1.77	....	....	....
Aug. 16	Juice brown in color	1.083	1.085	18.81	18.81	1.2	1.4	13.8	14.7	1.3	14.3	3.84	2.70	3.27	....	....	....
Aug. 20	Seed as before	1.080	1.083	18.90	17.64	1.6	1.5	15.2	13.7	1.5	14.4	2.12	2.49	2.31	....	....	....
Aug. 22	Seed almost dry	1.081	1.082	....	....	1.4	1.4	15.3	14.0	1.4	14.7	....	....	....	....	....	....
Aug. 26	do	1.077	1.082	17.95	15.60	1.3	1.4	14.1	13.4	1.4	13.7	2.59	.82	1.21	....	....	....
Aug. 30	Butt turned red at center	1.080	1.080	19.16	....	.8	1.2	12.4	12.1	1.0	12.2	4.00		....	....	....	....
Sept. 8	Ripe; seed dry	1.081	1.082	20.11	19.35	.7	.8	8.7	10.3	.75	8.35	?10.71	8.25	9.48	....	....	....
Sept. 13	Ripe; seed carried off by birds	1.081	1.080	19.33	19.40	.5	.6	....	16.4	.55	....		2.40	....	....	....	....
Sept. 15	Ripe and dry	1.080	1.080	18.95	18.40	.6	.7	11.3	13.9	.65	12.6	7.05	3.80	5.42	....	....	....
Sept. 20	do	1.073	1.075	17.12	15.97	.6	1.0	14.4	14.1	.8	14.25	2.12	.87	1.49	....	....	....
Sept. 27	Ripe and dry; largely suckered	1.082	1.078	17.05	18.32	.7	1.2	15.8	14.6	.95	15.2	.55	2.52	1.53	14.1	15.3	14.7
Oct. 3	do	1.072	1.075	19.14	16.84	1.1	1.1	14.6	13.7	1.1	14.15	3.44	2.04	2.74	13.9	13.4	13.65
Oct. 13	Ripe and dry; juices bright red	1.074	1.077	19.08	17.62	.9	1.0	14.7	13.4	.95	14.05	3.48	3.22	3.35	14.15	....	....
Oct. 21	Juices bright red	1.068	1.068	16.37	16.31	1.1	1.1	11.1	12.5	1.1	11.8	4.17	2.81	3.49	....	....	....
Oct. 29	Leaves killed by frost	1.079	1.081	19.48	19.49	1.5	2.7	14.3	13.5	2.1	13.9	3.68	3.29	3.48	....	....	....
Nov. 8	Quite dead	1.070	1.077	18.86	15.75	2.9	5.2	12.8	8.4	4.0	10.6	3.16	2.15	2.65	....	....	....
	Foreign.																
Sept. 17	Seed just brown; not in milk	1.051	1.053	13.25	12.94	4.9	7.2	7.4	5.2	6.05	6.2	.95	.54	.74	....	....	....
Oct. 1	Browning, but not much milk	1.068	1.069	16.77	16.24	8.9	9.9	8.2	7.1	8.55	8.50	....	....	....	....	....	....
Oct. 8	Brown and in milk	1.065	1.069	?13.16	17.64	4.9	8.3	11.6	....	6.65	....	....	....	....	....	....	....
Oct. 24	Brown and hard	1.087	1.087	16.77	21.12	2.3	3.9	17.2	16.8	3.1	17.00	....	.42		....	....	....

LIBERIAN.

Date.	Development.	Number of stalks used for analysis.	Length of topped stalk, in feet.	Length of top, in feet.	Length of butts.	Diameter of butt, in feet.	Weight of stalk, in pounds.	Weight of stalk stripped, in pounds.	Weight of top.	Weight of butt.	Per cent of water in top.	Per cent of water in butt.	Average per cent of water in cane.	Weight of juice from tops.	Weight of juice from butts.	Total weight, juice, in pounds.	Per cent of juice in entire cane.	Specific gravity of juice from tops.
Aug. 6	Flower stalk just out, compact	2	4 8	2 7	2 1	063	2.72	1 82	....	....	83 03	....	....	.430	.440	.870		1 033
Aug. 6	Flower spreading a little	2	8.1	5.8	2 3	.083	4 10	2.82	...		83 55	84 42	83 99	630	710	1 340	32 7	1 044
Aug. 12	Seeds beginning to brown	2	5 7	3.3	2 4	083	3 60	2 52	...	....	79.17	84 15	81 66	.540	670	1 210	33 7	1 061
Aug. 19	Seeds browner	2	6 4	4 4	2 2	.075	3.58	2.22	..	....	74 49	83 05	78 77	.450	570	1 020	29 0	1 067
Aug. 29	Seeds soft but not milky	2	6 6	4 4	2 2	075	3 28	2 28	....	.	67 88	70.81	69.35	.430	490	920	28 2	1 074
Sept. 8	Seeds still green in parts, and milky	2	5 8	3.5	2 3	.093	5 62	3.55	...	..	71 84	76 46	74 15	769	944	1 713	30 4	1 073
Sept. 13	Seeds dropping and hard	1	7 1	4 7	2.4	.100	2.86	1.82	.91	91	70 01	72.54	71.27	395	410	805	28 1	1 085
Sept. 20	Seeds nearly gone	2	5 7	3 6	2 1	079	4 17	2 43	1 21	1 22	76 98	72.21	74 09	571	586	1 157	27 7	1 082
Sept. 27	do	2	4 9	2 9	2.0	082	3 27	1 89	93	.96	70 75	75 04	72 89	417	417	834	25 5	1 081
Oct. 3	Dry and ripe	2	5 8	3 86	1 9	082	4.10	2 23	1 31	.92	76 10	66 61	71.35	.516	490	1 006	24 5	1 086
Oct. 14	do	2	6 0	4 0	2 0	088	4 49	2 29	1 08	1 21	66.55	73 00	69 77	476	670	1 146	25 5	1 081
Oct. 21	Dry and ripe, red juice	2	6 1	4 0	2 1	081	4 43	2 35	1 05	1 30	69 88	71 93	70 90	428	553	.981	22 1	1.077
Oct. 29	Dry, and leaves killed by frost	2	5 2	3.2	2 0	075	3 65	2 26	1.03	1 23	67.87	71 15	69.51	553	.578	1 131	31 0	1.076
Nov. 8	Quite dead	2	5 6	3.6	2.0	088	3 21	2.30	1 05	1.25	70 09	74 36	72.22	.511	.657	1 168	36.4	1.086
	Foreign.																	
Sept. 11	Seed just forming (D. Smith)	2	7 4	4 6	2 8	083	2 84	2.30	1.16	1 14	.....	....	75.07	....	....	.814	28 7	.....
Sept. 17	Seed just browning (D. Smith)	2	7 4	5.3	2.1	062	1 68	1 31	65	.65	71.62	72.59	72 10	.315	.309	.624	37 1	1.065
Sept. 30	Seed in the milk	3	6.1	...	...	059	2 52	1.88		..	73 39	72.39	72.89	.328	.368	696	27 6	1 079
Oct. 8	Seed in dough	2	6.4	3.6	2 8	.065	3.09	2.26	1.06	1 20	68.55	70.63	69.59	.457	.494	.951	30 8	1 082

LIBERIAN.

Date.	Development.	Specific gravity of juice from butts.	Average specific gravity of juice.	Per cent solids in juice from tops.	Per cent solids in juice from butts.	Per cent glucose, tops.	Per cent glucose, butts.	Per cents sucrose, tops.	Per cent sucrose, butts.	Average per cent glucose.	Average per cent sucrose.	Solids not sugar in juice, from tops.	Solids not sugar in juice, from butts.	Average per cent solids not sugar in juice.	Per cent sucrose, by polarization, tops.	Per cent sucrose, by polarization, butts.	Average per cent sucrose by polarization.
Aug. 6	Flower stalk just out, compact	1 041	1 037	6 87	8 83	5 9	5.2	1 0	2.7	5 55	1.85		92	...	....	...	.....
Aug. 6	Flower spreading a little	1 048	1 046	9.02	9.84	6.2	6 3	2 7	3.4	6 1	3 05	1 2	14	13	..	...	.....
Aug. 12	Seeds beginning to brown	1 057	1 039	12 70	12.09	5.2	4 2	6 3	6 3	4 6	6.3	1 2	.59	89	...	..	.....
Aug. 19	Seeds browner.	1 063	1 065	14.00	12 12	4.6	5 9	7 1	5 8	5.25	6 45	2 3	.42	1 36	..	..	.....
Aug. 29	Seeds soft but not milky	1 072	1 073	15 73	15 14	3.6	3 2	12 9	11.4	3.4	12 15	..	.54	..	..	.	....
Sept. 8	Seeds still green in parts and milky	1 071	1 072	17 79	18 01	1.7	2 8	10 5	7 6	.....		..	..		.	..	....
Sept. 13	Seeds dropping and hard	1.081	1 083	20 21	22 33	.9	2 0	15 2	12 6	1 45	13 9	4.11	5 73	4 92	..		....
Sept. 20	Seeds nearly gone	1 081	1 081	20 21	17 52	1.4	2 6	14 2	13 3	2 0	13 75		62		..		....
Sept. 27	do	1 081	1 081	18 43	18 20	1.2	1.7	14 6	14 4	.95	14 50	2 63	2 33	48	.	15 2	...
Oct. 3	Dry and ripe.	1 079	1 082	20 44	23 73	1.6	3 2	11 4	11 9	2 4	11 65	7 44	8 63	8 03	15 3	13 5	14 4
Oct. 14	do	1 082	1 081	18 61	19 11	1 3	1 9	14 7	15 4	1 6	15 05	2 61	1 81	2 21	14.2	15 2	14.7
Oct. 21	Dry and ripe. red juice.	1 077	1 077	18 37	19 60	1.3	1.5	13.8	15 5	1 4	14 85	3 27	2 60	2 93	..	.	....
Oct. 29	Dry, and leaves killed by frost	1 077	1 076	17 83	18.51	2 1	1.6	12 5	13 8	1 85	13 15	3 23	2 42	2 83	..	....	. . .
Nov. 8	Quite dead	1.082	1 084	19 61	19 39	4.8	2 8	12 3	14 3	3 8	13 3	2.51	2 29	2 40	..	....	....
	Foreign.																
Sept. 11	Seed just forming (D. Smith)	...	1 065	15 28		.	.			6 3	6 9	..	...	2 08	....	..	.....
Sept. 17	Seed just browning (D. Smith)	1 058	1 061	15 59	14 37	6 9	7 7	6 9	6 6	7 3	6 7	1 79	17	.98	..	.	...
Sept. 30	Seed in the milk.	1 075	1 077	19 04	17 89	11 0	13 2	8 1	6 0	12 1	7 0	..	..	...	4 9	3 2	4 90
Oct. 8	Seed in dough	1 078	1 080	15 16	19 05	7 8	10 1	9 3	7 5	8 5	8 8		1 45	..	7.2	5 2	6.2

HONDURAS.

Date.	Development.	Number of stalks used for analyses.	Length of topped stalk, in feet.	Length of top, in feet.	Length of butt, in feet.	Diameter at butt, in feet.	Weight of whole stalk, in pounds.	Weight of stalk stripped.	Weight of top, in pounds.	Weight of butt, in pounds.	Per cent of water in top.	Per cent of water in butt.	Average per cent of water in stock.	Weight of juice from tops, in pounds.	Weight of juice from butts, in pounds.	Total weight of juice in pounds.	Per cent of juice in entire cane.	Specific gravity of juice from tops.
Aug. 12	No sign of flower stalk; cane 7 ft. high	2	5.8	...	..	....	6.76	5.02	....	....	...	83.99	..	1.17	1.15	2.32	34.4	1.032
Aug. 19	Flower stalk just out	2	7.2	4.3	2.9	.104	7.34	5.48	...	....	83.83	84.15	83.99	1.26	1.42	2.68	36.5	1.037
Aug. 29	Flower stalk spreading	2	9.1	.	....	.104	7.48	5.98	....	...	83.09	79.67	81.33	1.18	1.85	3.03	37.7	1.040
Sept. 10	Stamens just fallen; no milk	1	10.1	6.3	3.8	.093	3.21	2.57	..	...	73.51	81.53	77.52	.564	.677	1.241	38.6	1.047
Sept. 10	Beginning to brown	1	9.5	6.1	3.4	.125	3.85	2.88	1.25	1.63	80.51	81.73	81.12	.670	.765	1.435	37.2	1.056
Sept. 15	In first milk; browning	1	9.7	7.5	2.2	.114	4.32	3.33	1.58	1.75	75.29	80.29	77.79	.730	.811	1.541	35.6	1.057
Sept. 19	In milk, brown	1	9.1	5.8	3.3	.093	2.76	1.98	1.02	.96	75.00	75.78	75.39	.426	.427	.853	30.9	1.057
Sept. 25	Full milk	1	9.8	6.6	3.2	.098	3.21	2.53	1.17	1.36	77.03	80.26	78.64	.542	.670	1.212	37.4	1.059
Sept. 25	...do	1	9.2	6.0	3.2	.115	4.08	2.90	1.27	1.63	76.10	77.10	76.60	.525	.717	1.242	30.4	1.060
Oct. 4	Dough	1	9.9	6.4	3.5	.121	4.06	3.00	1.35	1.65	72.52	75.52	74.02	....	.743	....	..	1.070
Oct. 14	...do	1	10.8	7.2	3.6	.112	4.08	2.94	1.39	1.55	64.15	69.19	66.62	.520	.642	1.162	28.4	1.074
Oct. 20	Harder	1	10.5	7.0	3.5	.112	3.75	2.79	1.29	1.50	68.27	70.52	69.39	.503	.644	1.147	30.6	1.080
Oct. 20	Harder; leaves dead	1	10.3	6.7	3.6	.088	3.38	2.92	1.23	1.69	68.85	74.00	71.42	.536	.633	1.169	34.5	1.077
Nov. 8	Quite dead	1	10.2	6.7	3.5	.105	3.09	2.69	1.25	1.44	69.21	72.27	70.74	.586	.759	1.345	43.5	1.086
	Foreign.—D. Smith.																	
Sept. 17	Not brown nor milky; heads well out	1	8.3	5.4	2.9	.114	1.85	1.49	.70	.79	67.22	76.55	71.88	.276	.373	.649	35.0	1.047
Oct. 1	Young; flower tops spreading	2	10.8	8.2	2.6	.082	2.58	2.07	1.02	1.05	64.46	68.96	66.71	.284	.392	.676	26.2	1.066
Oct. 8	Browning	2	9.0	6.1	2.9	.125	5.81	4.48	2.03	2.45	57.39	76.72	67.05	.860	1.036	1.896	32.6	1.075
Oct. 24	Tall stalk; seed first milk	1	7.7	4.6	3.1	.115	3.08	2.61	1.30	1.31	75.77	74.35	75.06	.624	.754	1.378	44.7	1.075
Oct. 24	Shorter and more stalky and riper	2	6.2	3.9	2.3	.092	2.83	1.85	.87	.98	63.04	62.35	62.69	.247	.351	.598	21.1	1.065
	Arsenal.																	
Sept. 30	Seeds not filled out	1	8.2	5.0	3.2	.092	2.19	1.81	.85	.96	79.40	78.10	78.75	.445	.529	.974	44.4	1.050
Oct. 15	Seeds greenish brown	1	9.7	5.9	3.8	.102	2.15	1.79	.77	1.02	76.81	.....	......	.373	.531	.904	42.0	1.054

HONDURAS.

Date.	Development.	Specific gravity of juice from butts.	Average specific gravity of juice.	Per cent solids in juice from tops.	Per cent solids in juice from butts.	Average per cent solids in juice.	Per cent glucose in juice of tops.	Per cent glucose in juice of butts.	Per cent sucrose in juice of tops.	Per cent sucrose in juice of butts.	Average per ct. glucose in juice from cane.	Average per ct. sucrose in juice from cane.	Solids not sugar in juice from tops.	Solids not sugar in juice from butts.	Average per cent. solids not sugar in juice.	Per cent sucrose by polariscope, tops.	Per cent sucrose by polariscope in juice of butts.	Average per cent sucrose by polariscope in juice.
Aug. 12	No sign of flower stalk; cane 7 feet high	1.037	1.035	6.04	6.97	6.50	4.10	6.2	1.7	.8	5.13	1.2	.24	...		....	.....	.....
Aug. 19	Flower stalk just out	1.042	1.040	7.63	8.46	8.04	5.4	5.0	2.2	3.4	5.20	3.8	.03	...	...	.	.....	.....
Aug. 29	Flower stalk spreading	1.045	1.043	8.27	9.44	8.80	4.9	5.1	4.0	4.4	5.00	4.2	....	...	.....	.....	.....	.....
Sept. 10	Stamens just fallen; no milk	1.050	1.058	*	..	..	3.4	4.0	6.2	5.7	3.7	5.9	....	....	....	....	....	.....
Sept. 10	Beginning to brown	1.051	1.053	12.21	11.32	11.76	3.5	4.1	7.9	6.7	3.8	7.3	...	..	...	....	....	.....
Sept. 15	In first milk; browning	1.054	1.055	13.66	12.56	13.11	3.7	4.0	8.9	8.0	3.8	8.4	1.06	.56	.81	...	...	.....
Sept. 19	In milk, brown	1.057	1.057	13.82	14.60	14.21	2.8	3.1	8.5	8.7	2.9	8.6	2.52	2.80	2.66	....	....	.....
Sept. 25	Full milk	1.057	1.058	13.31	13.23	13.27	2.9	3.8	9.4	8.2	3.3	8.8	1.01	1.23	1.12	9.55	8.7	9.1
Sept. 29	do	1.061	1.060	13.92	14.20	14.06	2.4	3.3	10.6	10.4	2.8	10.5	.92	.50	.71	10.0	10.1	10.0
Oct. 4	Dough	1.066	1.068	17.09	16.61	16.85	2.2	3.5	13.0	11.6	2.8	12.3	1.89	1.51	1.70	12.2	10.7	11.4
Oct. 14	do	1.070	1.072	17.48	17.72	17.60	1.0	1.8	14.6	14.4	1.4	14.5	1.88	1.22	1.55	13.7	14.0	13.8
Oct. 20	Harder	1.079	1.079	22.78	19.40	21.09	1.2	1.4	14.9	15.4	1.3	15.1	7.68?	2.60	5.10	....	....	.....
Oct. 29	Harder; leaves dead	1.074	1.075	17.67	17.88	17.77	1.1	1.9	15.0	13.5	1.5	14.2	1.57	2.48	2.02	.....	....	.....
Nov. 8	Quite dead	1.075	1.080	19.54	17.35	18.44	3.9	3.1	13.4	12.7	3.5	13.0	2.24	1.55	1.89	....	.....	.....
	Foreign—D. Smith.																	
Sept. 17	Not brown nor milky; heads well out	1.044	1.045	10.77	10.49	10.63	5.6	5.7	3.6	3.6	5.6	3.6	1.52	1.19	1.35	..	.....	.....
Oct. 1	Young; flower tops spreading	1.058	1.062	11.96	13.25	12.60	10.9	11.4	3.4	3.7	11.1	3.6	...	..	.....	1.0	.7	.8
Oct. 8	Browning	1.062	1.068	12.77	14.68	13.72	6.8	8.1	5.6	5.7	7.4	5.6	.37	.88	.62	4.2	4.2	4.2
Oct. 24	Tall stalk; seed first milk	1.070	1.072	18.14	17.17	17.65	4.3	6.5	13.0	10.7	5.4	11.8	.84	..	..	....	....	.....
Oct. 24	Shorter and more stalky and riper	1.069	1.067	14.34	14.05	14.19	4.6	6.4	7.1	5.8	5.5	6.4	2.64	.85	1.74	.....	.....	.....
	Arsenal.																	
Sept. 30	Seeds not filled out	1.052	1.051	11.73	13.01	12.37	8.0	7.1	3.1	5.4	7.5	4.2	1.91	...	.....	1.1	3.9	2.5
Oct. 15	Seeds greenish brown	1.054	1.054	.....	13.74	.....	7.5	8.8	4.5	4.1	8.1	4.3	...	.84	....	.....	.....	.....

* Burned.

COMPARISON OF THE UPPER AND LOWER HALVES OF SORGHUM-CANES.

	Per cent.
Average per cent of water in 17 specimens of Liberian sorghum..........tops..	73 05
Average per cent of water in 16 specimens of Liberian sorghum..... ..butts..	74 46
Average per cent of water in 20 specimens of Honduras sorghum........ tops .	72 57
Average per cent of water in 20 specimens of Honduras sorghum........butts..	76 15
Average per cent of water in 23 specimens of White Liberian sorghum....tops .	71 67
Average per cent of water in 23 specimens of White Liberian sorghum..butts..	75 22
Average per cent of water in 22 specimens of Early Amber sorghum..... tops..	72 73
Average per cent of water in 22 specimens of Early Amber sorghum.....butts..	72.13
Average per cent of juice from 10 specimens of Liberian sorghum........tops..	45.17
Average per cent of juice from 10 specimens of Liberian sorghum........butts..	49 89
Average per cent of juice from 16 specimens of Honduras sorghum .... .tops..	42 88
Average per cent of juice from 17 specimens of Honduras sorghum... ..butts..	45 44
Average per cent of juice from 13 specimens of White Liberian sorghum, tops .	42 63
Average per cent of juice from 13 specimens of White Liberian sorghum, butts.	44 50
Average per cent of juice from 11 specimens of Early Amber sorghum....tops..	46 68
Average per cent of juice from 11 specimens of Early Amber sorghum. butts..	50.58
Average specific gravity of juice from 17 specimens of Liberian sorghum, tops..	1.0725
Average specific gravity of juice from 17 specimens of Liberian sorghum, butts.	1 0708
Average specific gravity of juice from 21 specimens of Honduras sorghum, tops.	1.0602
Average specific gravity of juice from 21 specimens of Honduras sorghum, butts	1 0584
Average specific gravity of juice from 24 specimens of White Liberian sorghum, tops..	1.0753
Average specific gravity of juice from 24 specimens of White Liberian sorghum, butts..	1 0730
Average specific gravity of juice from 22 specimens of Early Amber sorghum, tops..	1.0765
Average specific gravity of juice from 22 specimens of Early Amber sorghum, butts ..	1.0771
Average per cent of solid matter in juice from 16 specimens of Liberian sorghum..tops..	16.21
Average per cent of solid matter in juice from 17 specimens of Liberian sorghum ....butts..	16 81
Average per cent of solid matter in juice from 19 specimens of Honduras sorghum ..... tops .	13 85
Average per cent of solid matter in juice from 20 specimens of Honduras sorghum .. butts .	13 82
Average per cent of solid matter in juice from 23 specimens of White Liberian sorghum. .. tops .	16.91
Average per cent of solid matter in juice from 22 specimens of White Liberian sorghum.. . butts .	16.71
Average per cent of solid matter in juice from 19 specimens of Early Amber sorghum. .. tops..	17.59
Average per cent of solid matter in juice from 21 specimens of Early Amber sorghum..........butts..	16 75
Average per cent of water in tops, 79 specimens	72 45
Average per cent of water in butts, 79 specimens,.	74 51
Average per cent of juice from tops, 50 specimens	43 96
Average per cent of juice from butts, 51 specimens.....	46 90
Average per cent of solids in juice from tops, 77 specimens..........	16 18
Average per cent of solids in juice from butts, 80 specimens..........	16 02
Average specific gravity of juice from tops, 84 specimens	10 71
Average specific gravity of juice from butts, 84 specimens..........	10 70

From the above comparison it will appear, that there exists no marked difference in the amount of juice present in the upper and lower halves of the canes, nor in the quality of this juice, as indicated by either the relative specific gravities or the total amount of solid matter present in the juices.

It will also appear that, during this early and immature state of the plant, the relative amount of crystallizable sugar (sucrose), as compared with the total sugars present, is much greater in the lower half of the canes. This condition remains, apparently, until the seed has reached the milky state, at which time the juices in both parts of the plant appear to be of equal value. But it must not be understood that the maximum content of sugar in the plant has been reached at

this period of development, since, as will be seen by the tables, this is far from the fact.

From this period in the plant's development, until the perfect ripening of the seed, the juices appear to uniformly increase in their content of crystallizable sugar, and to decrease in their content of uncrystallizable sugar.

Still later in the growth of the plant, there was observed a slight deterioration in the quality of the juices from the lower halves of the stalks, and they were generally found to be somewhat inferior to the juices at this time present in the upper halves. It was also found that, in the early examinations, the specific gravity of the juices from the lower halves was almost invariably greater than that of the juices from the upper halves, and that equal specific gravities indicated an equality between the juices, not only in their content of sugar, but in the relative proportions of sucrose and glucose.

It appears probable that this deterioration of the juice from the lower part of the cane marks the incipient stages of death, and the ultimate decay of the plant, the roots and leaves failing in their office to supply the full amount of nourishment which the plant requires. It begins to feed upon itself, so to speak; and it is to be observed, that, at this period, the offshoots from the upper joints of the stalk begin a vigorous growth, and appear to live as parasites upon the parent stalk.

Several experiments were also made with both corn-stalks and sorghum to determine the relative value of the upper and lower half of the stalks, with the results given in the following table:

	Percentage of juice to stalks.	Specific gravity of juice.	Percentage of syrup in juice.
Corn-stalks, butt ends, No. 3	29.04	1053	14 62
Corn-stalks, top ends, No. 4	19 94	1050	13.46
Sorghum, butt ends, No. 8	47 49	1059	16.41
Sorghum, butt ends, No. 10	41 49	1062	16 47
Sorghum, top ends, No. 9	43.16	1057	14 70
Sorghum, top ends, No. 11	34 09	1059	14.26

Nos. 8 and 9 were the butts and tops of the same stalks, and were cut just after a rain, as were also Nos. 10 and 11, from which the rain had evaporated, and the difference in yield of juice and syrup between butts and tops is nearly constant. The increase in specific gravity of the juice from butts over that from the top is also worthy of notice.

From the above table the conclusion from the average results is, that the proportion, by weight, of sugar in the lower half of the stalk, is to the sugar in the upper half as follows: Corn butts to corn tops as 159 to 100; sorghum butts to sorghum tops as 131 is to 100. As

will be seen by reference to the first table, the stalks of both corn and sorghum in the above experiment were divided almost equally by weight into butts and tops, so that the above proportion fairly represents the proportion of yield of sugar in the upper and lower half of the cane. There was a marked difference in the appearance of the juice as it flowed from the mill (that from the butts being lighter in color, especially in the experiments with corn); but, after the clarification, no appreciable difference could be observed, nor was there any difference in the product except the quantitative one above mentioned, which was, however, a marked difference; also, there was a marked difference in granulation in favor of the juice from the butts.

The following analyses are reported by Professors Scovell and Weber. It will be observed that the great difference in the analyses does not accord with the slight difference in specific gravity.

Comparison of the lower and upper half of the cane.—The two following analyses were made to show what part of the cane is richest in sugar:

Amber—October 2nd, 1880.—Juice obtained from the upper half of the stalks after topping as usual:

Specific gravity		1.069
Grape sugar	per cent	2.94
Cane sugar	per cent	9.67

Amber—October 2nd, 1880.—Juice obtained from the lower half of stalks:

Specific gravity		1.070
Grape sugar	per cent	1.94
Cane sugar	per cent	11.64

The Encyclopedia of Chemistry II., 901, gives the following analyses by F. N. Gill, Madras, India, of the top, middle, and butts of two samples of sugar-cane:

	Water.	Sugar.	Fiber.	Salts.	Glucose.	Unknown.
Top	78.33	10.63	7.63	.31	2.64	.46
Middle	75.61	13.31	8.47	.26	1.51	.84
Butt	76.12	13.37	8.30	.23	1.54	.46
Top	79.48	9.49	7.58	.55	2.43	.47
Middle	75.63	13.64	8.65	.36	.74	.98
Butt	75.95	13.85	8.29	.35	.71	.86

It will be seen that the sugar-cane closely resembles sorghum, in the relative value of the juices from different parts of the stalk. The inferior quality of the tops is due to the fact, that the growing part of the cane is always in a condition of immaturity; and, knowing this, the planters are accustomed to leave, as trash in the field, the upper portion of the cane, knowing that it is worthless for sugar making.

Owing to the fact that it is often advised to cut the crop two or three joints above the ground, under the belief that the butts were worthless for either syrup or sugar, the following experiments were

made to ascertain whether such a course was advisable, in fact, whether it did not involve a large waste of sugar. Since, in the experiments above recorded, the stalks were divided, as nearly as possible into halves by weight, it might still be true that the butts of the cane were practically worthless; therefore, in the following experiments, the stalks were cut as low down as possible, and were divided into butts, middle, and tops, the analysis of each of which appears in the following table.

In each experiment 27 or 29 canes were taken. In the one case the seed was hard, and in the other in dough. In the former, each cane was divided in about equal parts by length into butt, middle, and top; and, in the latter case, the portion called butt was such portion as might naturally be left upon the field if the crop should be cut at the second or third joint. It will be seen that, in this latter case, the relation of butt to middle and top was in length as 1 to 8, and in weight of stripped stalk as 1 to 4.6:

ANALYSES OF JUICES FROM BUTT, MIDDLE, AND TOP, OF SORGHUM STALKS.

Variety.	Condition of seed.	Number of canes.	Part taken.	Length in feet.	Stripped weght in pounds.	Juice expressed, pounds.	Per cent of juice expressed.	Per cent of glucose in juice.	Per cent of sucrose in juice.	Per cent of solids not sugar in juice.	Polarization of juice.	Per cent of available sugar in juice.
Early Amber	Hard	27	Butt	2 0	8 68	5 25	60.46	1.15	10 27	3.01	10.53	6 11
... do	..do	27	Middle	2 2	7 94	4 80	61.21	1.00	10 77	3 03	10.54	6 74
... do	. do	27	Top.	2.4	4 22	2 48	58 79	.82	11.33	3 38	11.16	7 13
do	.do	27	Entire cane	6 6	20 84	12 59	60 41	1.05	10 92	3 34	10 61	6.53
White Liberian	Dough	29	Butt	8	3 51	1.91	54 43	.85	12 65	4 07	13 09	7 73
......do	..do	29	Middle	2.3	8.73	5 13	58 80	.94	11 64	3 84	12 14	6.86
......do	..do	29	Top.	3 7	7 53	4 40	59 23	73	11 82	4 47	12 09	6.62
......do	..do	29	Entire cane	6 8	19 77	11 50	58.19	88	12.04	3.28	12.28	7.88

From the above table it will be seen that there was practically very little difference in the juice obtained from butts, middles, or tops, either in the amount expressed by the mill or in its composition. It will be also observed that, in the maturer cane, the juice from the butts was in its per cent of sucrose and available sugar slightly less than that from the middle, while that from the tops was best of all. In the cane, however, the seed of which was in the dough, exactly the reverse was true, the juice from the butts being the best of all. It is, therefore, safe to say, that the crop should be cut as near the roots as possible, whether intended for sugar or syrup, since, as will be seen, the butts, though only about 9 inches long, equaled about one-fifth the weight of the cane.

GENERAL ANALYSES OF SORGHUM JUICES BY VARIOUS PERSONS.

The following published results of analyses of sorghum juices are given for purpose of confirming, so far as they go, the more extended results secured at the Department of Agriculture already recorded, and also as evidence that these results are not exceptional, since they have been, to a great extent, reproduced in many sections of the country, notably in Massachusetts, by Professor Goessmann; in New Jersey, by Professor Cooke and Mr. Hughes; in Wisconsin, by Professors Henry and Swenson; in Illinois, by Professors Weber and Scovell; and in Indiana, by Professor Wiley; as also in France, by M. Louis Vilmorin.

In reviewing these several reports, it will be seen that, in very many instances, they are vitiated by the absence of certain data which would greatly increase their scientific and practical value, and the conclusions often are hardly such as are justified by data so limited. For example, M. Louis Vilmorin, in 1853, had secured results from sorghum fairly comparable in the content of sugar shown to be present in juice, with those more recently obtained; but at present no one, I think, will agree with him in saying that the maximum of sugar is reached "when the seeds are in the milky stage," and his conclusion as to the sugar being more abundant in the middle of the stalk than in the lower or upper portion.

The very close resemblance between the analyses of Prof. Henry, showing the "Development" of sugar, to those obtained at the Department of Agriculture, is marked; and, his conclusion, that "the cane sugar gradually and rapidly increased, while the glucose slowly decreased, from the time of flowering to the maturity of the seed," is the exact result established, year after year, with every variety of sorghum cultivated at Washington. It is, however, to be regretted, that the examinations of the cane were suspended October third, as the increase in sugar, constant up to and including that date, would doubtless have increased after, and have fully confirmed, for Wisconsin, results thus far secured at Washington, and shown to be true in Boston, Mass., by Prof. Sharpless, in his analysis of the sorghums grown by Henry B. Blackwell, in 1882, in the juice of which 18 per cent of sucrose was found, equal to the best sugar-cane of Cuba.

In view of such a result, it is hardly to be wondered at, that the legislature of Massachusetts should have provided by law a bounty to encourage the development of this new industry.

The analyses of Professors Scovell and Weber, in the main, sustain those made in Wisconsin and Washington, but appear to justify the conclusion that the maximum content of sugar is at the time when

the seed is in the "hardening dough" state. But it is to be said, that only two varieties were carried beyond that state of maturity; and this matter is one of such great practical importance, that a fuller discussion of these apparent exceptions appears justified.

Their results with these two were as follows, averaging the analyses:

Development.	Orange.			Amber.		
	Sp. grav.	Glucose.	Sucrose.	Sp. grav.	Glucose.	Sucrose.
Beginning to head	10 55	5.70	4.90	10 58	8 39	3.38
In blossom	10.62	6 10	7.12	10 66	5 43	8 42
In milk	10 55	5 90	6 01	10 67	3 80	10 30
In hardening dough	10 65	4 11	9.76	10 69	3.02	12 56
Ripe seed	10.78	4 02	11.41	10.68	2.65	10 93

From this it appears that these results show, that as at Washington so in Illinois, the "Orange" cane was at its maximum content of sugar when the seed was ripe, and had increased 1.65 per cent in amount over that present when the seed was in the "hardening dough." On the other hand, the "Amber" had fallen off 1.63 per cent in its content of sugar between the "hardening dough" stage and ripe seed. In neither case were the examinations, as reported, carried beyond this stage, and as the matter stands there is at least an even case. In explanation of such a result with the Amber, it has been found often true of many varieties, that, during the period of ripening of the seed, there is a slight falling off in the content of the sugar in the juice, as though the demands of the plant at this period for material from which to elaborate the seed was a little in excess of the production of this material, and that there was, therefore, a drawing upon the supply already stored up in the plant; but it was found invariably, as an average result of all the varieties under investigation each year, that, so soon as the seed had ripened, this slight deficiency in sugar in the juice was not only speedily made good, but that the amount of sugar actually increased in the plants. This will be made clear by the consideration of analyses made in Washington of a few of the many varieties which have shown such deportments; as, for example, Early Amber, Early Golden, Golden Syrup, Early Orange, Neeazana, and others.

But by reference to the charts showing the average results of all the varieties for 1879–82, it will be seen, that the maximum of sugar was in every case attained after the seed was ripe, and was maintained long afterward.

M. Louis Vilmorin on Sorghum.

M. Louis Vilmorin, of Paris, the well-known seedsman, in 1854, published in the *Bon Jardinier* Almanac for 1855, pages 41–53, an article on *Sorgho sucré* of much interest, from which it appears that sorghum was grown as a sugar plant at Florence, in 1766, by Pietro Arduino, and also that M. d'Abadie sent to the Museum in Paris from Abyssinia a collection of seeds containing thirty varieties of sorghum, some plants of which attracted attention from the sugary flavor of their stems. M. Vilmorin calls attention, especially, to the fact, that while the seeds of sorgho from the new importation of Montigny from China, in 1851 (see Dr. Williams' notes on the Chinese sorghum, p. 53), were black, and apparently identical with those of the old collections, the seeds of the Florentine plants were described as of a clear-brown color, corresponding to well-recognized differences in the sugar sorghum.

I have not extracted any sugar from sorghum; I have only made some determinations by means of the saccharometer, and verified them generally by means of evaporation and a treatment with alcohol.

The following are the results presenting the proportion of sugar existing in the juice from plants gathered at Verrières:

	Per centum.
October 13th, 1853	10.04
November 28th, 1853	13.08
November 28th, 1853, second experiment	14.06
October 13th, 1854 (without inversion)	10.14
November 15th, 1854, crystallizable sugar, 11¾ per cent; uncrystallizable sugar, 4¼ per cent	16.00

Our calculations, on the basis given above, would show that the returns of one hectare of sorghum would be as follows:

Stalks and leaves	kilograms	77,270
Net stalks	do	49,300
Juice, at 55 per cent to the weight of stalks (271 hectoliters)	liters	27,115
Sugar, at 8 per cent to the juice	kilograms	2,169
Absolute alcohol, at 6.3 per cent to the juice	liters	1,708

The analogous returns from the beets would be as follows:

Roots, weight to the hectare	kilograms	45,000
Juice, at 80 per cent to the weight of roots	do	36,000
Sugar, at 6 per cent to the juice	do	2,160
Absolute alcohol, at 3 per cent to the beets	liters	1,350

The 8 per cent sugar on which I have calculated the yield of sorgho will, perhaps, be considered as too low; but it should not be forgotten that it refers to the crystallizable sugar that can actually be extracted, and I do not, therefore, believe my estimate too low. If I were to make a comparison between the "sorgho" and the "sugar-cane" in a more southerly climate, I have no doubt that the figure representing the product in sugar would rise to a far higher value; but I lack the data required for such a comparison.

After examining the chances of the industrial culture of sorgho, and the considerations that may lead to the adoption of this plant, I have only to furnish

some data obtained from our first experiments, which may afford some indications for further study, or some guide for the first attempts in manufacture.

One of the points which I have endeavored to establish, without, however, obtaining complete success, was this, viz: What is the time, during the period of vegetation, when the stalks begin to contain sugar, and, consequently, what is the moment when the manufacture may commence? It appeared to me that this time coincided with that of the appearance of the ears; but the proportion of sugar existing in the cane keeps on increasing up to the time when the seeds pass into the milky stage. I have noticed that the richness in sugar in a plant while blooming, diminished gradually from the lower to the upper part of the stalk in the spaces between the joints, and also that the lower portion of each one of these interspaces is younger and less rich in sugar than the upper one. Such being the case, the middle of the stalk is the richest portion, for the lower joints are hard and small. I have not been able to ascertain it with exactness, but I suppose that at a later period the spaces between the joints in the lower part of the stalk become impoverished, or, if the juice does not grow poorer, it at least diminishes in quantity.

The ripeness of seeds does not seem to reduce, to any considerable degree, the production of sugar, at least in our climate; but as maturity is reached at the end of the season, and our plants, consequently, continue to advance in richness with the development of vegetation, the effect of maturity on these phenomena can hardly be determined. This question can be solved only in those countries where the seeds of the plant mature before the warm season is over. According to M. de Beauregard's report, addressed to the "*Comice de Toulon*," maturity would seem to have had no injurious influence within the limits of his experience; and he considers seed and sugar as two products, which can be obtained jointly. On the other hand, the Zulu Caffres are accustomed to snatch, by an abrupt pull, the panicles away from their plants as soon as they show themselves, in order to increase the sugary quality of the stalks. But this question has, after all, no importance in respect to France, since here ripeness will never take place too soon to prove detrimental.

The following analyses were made by Professors Henry and Swenson, of Wisconsin State University, in 1881–2, and, as they say, the conclusions to be drawn from them are very indefinite. It is unfortunate that the development of each sample is omitted from their report.

Character of soil.	Time of planting.	Date of cutting.	Number of stalks.	Weight of stalks.	Per cent. of juice expressed.	Per cent of cane sugar in juice.	Per cent of glucose in juice.	Time of analyses.	Variety.
Sandy loam	May 15.	Oct. 5.	12	18	48.0	7.29	3.94	Oct. 8.	Early Orange.
Sandy loam.	May 20.	Oct. 5.	12	12½	60.0	11.14	3.40	Oct. 8.	Early Amber.
Clayey			12	8	53.1	6.50	5.45	Oct. 10.	Early variety.
Clayey	May 15.	Oct. 6	13	10¾	58.8	9.92	2.96	Oct. 10	Early Amber.
Clay loam	J'ne 23.	Oct. 5.	12	10¾	62.8	6.25	5.12	Oct. 10.	Early Amber.
Sandy loam	May 26.	Sep. 6.	12	12½	52.0	12.83	2.94	Oct. 10.	Early Amber.
			5	6¾	55.5	10.94	3.59	Oct. 11.	Early Amber.
Heavy clay loam	May 15.		12	10¾	55.8	4.88	5.23	Oct. 11.	Early Amber.
			12	9¾	59.0	8.98	3.45	Oct. 11.	Early Amber.
Sandy loam	May 20.		12	12½	56.0	7.01	4.50	Oct. 11.	Early Amber.
			5	5½	50.0	6.77	5.78	Oct. 11	Early Amber.
			11	13	61.5	7.08	5.36	Oct. 11	Early Amber.
Light loam	May 15.	Oct. 10	12	12	52.0	13.11	3.22	Oct. 12	Early Amber.
Light loam	May 12.	Oct. 10.	12	11¾	51.1	13.63	2.65	Oct. 12	Early Amber.
Black loam	May 26.	Oct. 6.	12	15½	56.4	10.87	2.59	Oct. 12	Early Amber.
Clay.	May 26,	Oct. 6	12	8	54.3	6.00	8.43	Oct. 12	Early Amber.
Prairie loam	June 3.	Oct. 6.	12	12	58.3	6.23	7.56	Oct. 12	Early Amber.
Sandy loam	June 1.	Oct. 12	12	7¾	58.1	6.21	3.98	Oct. 14	Early Amber.
Clay land	May 5.	Oct. 12.	12	14	60.7	7.61	4.50	Oct. 14	Early Amber.
Clay land.	June 1.	Oct. 12	12	8¾	54.3	6.59	3.96	Oct. 14	Early Amber.
Sandy loam	May 10.	Sep. 24.	12	11	63.6	10.31	6.02	Oct. 14	Early Amber.
Black loam	May 16.	Sep. 28.	12	11½	71.7	4.70	5.49	Oct. 14	Early Amber.
Very sandy	May 12.	Sep. 26.	13	11¼	66.8	9.07	5.36	Oct. 14	Early Orange.
Sandy loam	May 25.	Oct. 6	12	13	57.7	4.50	9.50	Oct. 14	Stewart's Hybrid.
Clay.	May 12.	Oct. 8.	12	6¾	51.8	8.70	8.20	Oct. 21	Golden Imphee.
Wash of barn-yard	May 24.	Oct. 11.	6	4¼	58.8	5.77	5.60	Oct. 21.	Early Amber.
Clay	May 15.	Oct. 2	9	5	55.5	8.78	5.62	Oct. 21	Early Amber.
			12	14½	51.7	6.73	6.90	Nov. 2	Kansas Orange.
Clay soil	May 20.	Sep. 10.	12	11½	58.7	6.43	5.52	Nov. 2	Early Amber.
Black soil	May 20.	Sep. 10.	12	15¾	49.0	7.15	6.85	Nov. 2	Early Amber.

It is hardly possible to draw any definite conclusions from the above analyses, as many samples were not received for several weeks after being cut. It will be seen, however, that nearly all those samples which were analyzed within but a few days after being cut contain a large proportion of cane sugar, while those which were analyzed after a longer period of time show a high content of glucose and a low proportion of cane sugar. This corroborates my statement in the first part of this report, and shows the necessity of working up the cane directly from the field, in order to get the best results.

It will also be seen, that all the samples conspicuous for their high content of cane sugar are raised on a light soil, usually sandy loam, while those raised on heavy clay land contain large proportions of glucose. It, therefore, appears that, in order to obtain a maximum content of cane sugar, the cane should be grown on a light soil. For making syrup alone, the cane raised on clayey land will do about as well, as the high content of glucose will not materially affect the quality of the syrup.

Twenty-six varieties of cane were grown on the university farm during the past season, some of which were from seeds kindly sent by Dr. Collier. The following table shows the results of my examinations:

Variety of Cane.	Average weight of stalks.	Stage of the seed.	Per cent of cane sugar.	Per cent of glucose.
	Lbs. Oz.			
Chinese, No. 1	8	Dough	7.28	1 76
Chinese, No. 2	8	Milk	7 71	1 88
Chinese, No. 3	14½	Milk	7 26	1.78
Chinese, No. 4	9½	Dough	7 80	1 78
Chinese, No. 5	9	Dough	7 15	2 08
Chinese, No. 6	1 4	Milk	4 18	1.61
India, No. 1	1 6	Hard dough	9 45	1 65
India, No. 2	14	Hard dough	9 26	1 64
Honduras	1 6	Dough	8 91	3 12
Miller	10½	Ripe	10 18	2 44
Stump	1 6	Doughy	15 77	2.63
Goose Neck	1 1	Dough	13 02	2 42
White Mammoth	2	Milk	8.18	3 26
Gray Top	1 13	Milk	9 54	2 77
Neeazana	1 3½	Hard dough	9 12	3 22
Early Amber	1 2	Ripe	13 08	1.96
Link's Hybrid	1 12	Milk	11 88	1 77
Honey	2 2	Milk	9 22	3.45
Liberian	1 6½	Ripe	11 30	2 38
Kansas Orange	1 3½	Hard dough	10 99	2 32
Early Orange	1 14	Dough	7.16	3 57
White Liberian	1 14½	Doughy	11.14	1.78
Canada Amber	12	Ripe	10.74	2.97
Texas Amber	1 2½	Ripe	13.65	2.29
Illinois Amber	1 2	Ripe	11.62	1.65

The only variety used for sugar making was the Early Amber. Three separate plats were planted, of 3, 6, 2, and 1½ acres respectively. The latter plat was used for experiments with fertilizers.

Development.

The development of the Early Amber cane raised on this farm may to some extent be seen from the following analyses, which have been made by me during the summer and fall:

August 10:	
Cane sugar	3.00
Glucose	4.50
August 20:	
Cane sugar	8.20
Glucose	5 10
September 6:	
Cane sugar	9.22
Glucose	4.20
September 14:	
Cane sugar	9 96
Glucose	3 45
September 17:	
Cane sugar	9 86
Glucose	3.32
September 20:	
Cane sugar	10.02
Glucose	3.23
September 22:	
Cane sugar	11 05
Glucose	2.60

September 29:*	
Cane sugar	8.59
Glucose	3.50
September 29:*	
Cane sugar	8.60
Glucose	3.50
September 29:*	
Cane sugar	8.61
Glucose	3.44
October 3:	
Cane sugar	12.67
Glucose	2.43

From these we see that the cane sugar gradually and rapidly increased, while the glucose slowly decreased, from the time of flowering to the maturity of the seed. During the latter part of September, most of the cane was lodged by a very violent wind and rain storm. The juice from the stalks that were lodged was charged with a red coloring matter, the inside of the entire stalk being in many cases of a bright red color. Several of the stalks contained but a small portion of red coloring matter, but instead had a peculiar yellow and watery appearance, and quite a disagreeable taste. The juices from these contained on an average only 8 per cent sugar, and 4.8 per cent glucose.

The following letter, giving the results obtained by Mr. Blackwell, will be read with interest:

MAINE BEET SUGAR COMPANY, 5 PARK ST., BOSTON, *December 7th*, 1882.
To the Cane Growers' Association, St. Louis, Mo.

GENTS—Having been a sugar refiner, and, more recently, the treasurer and managing director of the Maine Beet Sugar Company, which made in two years (1879 and 1880) $200,000 worth of sugar and syrup from beets, raised in New England, I desire to make some practical suggestions for the manufacture of sugar from sorghum. I have recently become convinced, by the experiments of Prof. Collier, of the U. S. Department of Agriculture, Washington, D. C., that the juice of well matured sorghum is equal to that of the sugar-cane. This summer, I raised an experimental crop of "Early Amber" and "White Liberian," from seed obtained at Washington, in my garden here in Boston. In the last week of October, I cut this cane, fully matured, and still uninjured by frost. The juice gauged 11° Baume, when clarified, and proved so fine that I had it analyzed by S. P. Sharpless, state assayer, 114 State street, Boston, with the following result:

Water	78.18 per cent.
Cane sugar	18. "
Inverted sugar	2.09 "
Ash	.89 "
Gum, etc.	.84 "
	100.00

This juice had been defecated by lime in excess—the lime being mostly precipitated afterward by phosphoric acid. The "Ash" indicated above was largely lime and phosphate of lime held in solution, the result of defecation.

This being fully equal to average West India juice. I made a few pounds of

* This cane was lodged by storm.

sugar over the open fire, without the use of bone-black, or of any chemical except lime. I send you a sample of the sugar obtained. It was not washed in the centrifugal, and so is darkened by the adhering alkaline syrup. Still, the sample polarized 90 per cent pure sugar. I got exactly one-half the weight of the boiled syrup in this sugar at the first running. The syrup I filtered through bone-black to remove the lime. From it I got 50 per cent of sugar at second running, a sample of which I also inclose. Thus I obtained without any method of evaporation but open fire, 75 per cent of sugar from the boiled juice.

I kept a part of my canes for five weeks in a shed, a part of the time at a freezing temperature. December 4th, I worked some of these, and got, by the diffusion process, 10 per cent of weight of canes in excellent syrup, weighing twelve pounds to the gallon, and of quality equal to that from the same cane when first cut.

I will now make a few suggestions for the profitable making of sugar from sorghum. Two conditions are needed: 1. The cane should not be worked until nearly ripe; the seed should be hard before the cane is cut. 2. The same processes, so successfully applied to the beet in Europe, should be applied to the sorghum. These processes are, briefly, as follows:

1. The juice should be treated with a very considerable excess of lime, so as to make it decidedly alkaline, at a temperature not exceeding 160° F. Without this excess of lime, a perfect defecation is impossible.

2. The lime should then be almost wholly precipitated in the juice, by the injection of carbonic acid gas.

3. The slightly alkaline thin juice should then be filtered through cloth by filter presses, or otherwise.

4. It should then be passed through bone-black, and thoroughly decolorized.

5. It should then be boiled down, either by open evaporator, or, far better and cheaper, by exhaust steam in a double-effect vacuum pan to about 25° Baume.

6. It should again be filtered through fresh bone-black, to remove all color.

7. It should then be grained in the vacuum pan.

8. It should be purged in a centrifugal.

The first product should be standard granulated sugar; the second product should be bright yellow, and the third product light brown, refined sugar—a total product of about 75 per cent of the boiled juice. The process above described will be substantially adopted when the manufacture of sugar from sorghum is put upon its permanent business basis. It will be done, if at all, on a large scale, and with large profit.

The gumminess and difficulty of crystallization complained of in sorghum is due either to unripeness, or to injury by frost, or to an imperfect defecation. No properly defecated juice ever needs to be skimmed while boiling It must be remembered that syrups designed for sugar require different treatment from those which are not intended to crystallize. The presence of gum and vegetable matter add to the volume of syrup, without greatly deteriorating its color, if carefully handled, but is extremely detrimental to crystallization. No subsequent manipulation will cure an imperfect defecation.

Another important consideration is, that the mills now in use, no matter how powerful, do not express more than about two-thirds of the saccharine juice. These

should be supplemented, wherever plenty of water can be had, by a diffusion battery, whereby the whole of the sugar can be washed out of the cane by a stream of warm water (170° F.), which displaces and drives the sweet juice before it. This, however, can not be profitably done without a double-effect vacuum pan, whereby an economical evaporation is effected.

The improved processes above described are not my own invention, but are used in hundreds of factories here and in Europe. They can not be patented or monopolized, and are not likely ever to be superseded, because they are the result of a century of scientific research.

Yours, respectfully,

HENRY B. BLACKWELL.

Professors Weber and Scovell report the following results of their analyses, in 1880 and 1881:

TABLE SHOWING THE DEVELOPMENT AND CHANGE OF SUGARS IN SORGHUM.

Stage of development.	No.	Date.	Variety.	Specific gravity of juice.	Grape sugar.	Cane sugar.	Average of cane sugar.
Beginning to head	1	Aug. 14, 1880	Orange	1.055	5.70	4.90	4.14
	2	Aug. 10, 1881	Amber	1 058	8.39	3 38	
In blossom	3	Aug. 25, 1880	Orange	1 062	6 10	7.12	7.77
	4	Aug. 10, 1881	Amber	1.066	5 43	8 42	
Seed soft and milky	5	Aug. 14, 1880	Amber	1 065	3 34	10.75	
	6	Sept. 6, 1880	Orange	1 068	5 00	9 13	
	7	Aug. 10, 1881	Amber	1 068	4 25	9.84	
	8	Aug. 12, 1881	... do	1.070	3 75	12 75	8.56
	9	Sept. 1, 1881	Orange	1.048	6 11	3.71	
	10	Sept. 2, 1881	Orange	1 048	6 58	5.19	
Seed in hardening dough	11	Aug. 25, 1880	Amber	1 068	2 47	12 48	
	12	Sept. 16, 1880	Orange	1.065	4 11	9 76	
	13	Aug. 10, 1881	Amber	1.074	3 65	10.10	
	14	Aug. 12, 1881	...do	1 074	2 65	13.37	
	15	Aug. 16, 1881	.. do	1 070	3 92	11 89	
	16	Aug. 16, 1881	do	1 072	3.00	13 66	
	17	Aug. 19, 1881	.. do	1 067	3 46	12 49	
	18	Aug. 19, 1881	...do	1 074	3 10	13 18	11 95
	19	Aug. 19, 1881	...do	1 076	2 97	13 64	
	20	Aug. 19, 1881	...do	1 070	2 98	12 80	
	21	Aug. 19, 1881	..do	1 070	3 26	12.52	
	22	Sept. 1, 1881	Liberian	1 060	3.67	10.24	
	23	Sept. 1, 1881	Amber	1 063	2 61	13 47	
	24	Sept. 1, 1881	do	1 056	2 18	11 14	
	25	Sept. 1, 1881	Chinese	1.052	4 13	8 60	
Seed ripe	26	Sept. 6, 1880	Amber	1 064	2.13	11 42	
	27	Sept. 16, 1880	. do	1 065	2 79	11 02	
	28	Oct. 2, 1880	...do	1.069	2 47	10.06	
	29	Oct. 6, 1880	Orange	1 078	4 02	11 41	11.18
	30	Sept. 9, 1881	I. I.U	1.070	2 93	12 48	
	31	Sept. 1, 1881	Amber	1 070	2 71	10 77	
	32	Sept. 2, 1881	.. do	1.070	2 61	10.57	
	33	Sept. 5, 1881	...do	1.067	3.16	11 76	

The analyses made in 1880, numbers 1, 3, 5, 6, 11, 12, 26, 27, 28, and 29, were from cane grown upon the University farm.

FIELD CROPS IN 1882.

No.	Variety.	Date of planting.	Date of heading.	Date of hardening dough.	Days required.
1	Early Golden........	April 29	Augugt 8. ..	September 5....	128
2	Early Orange....	"	August 18 ...	September 24...	147
3	Minn. Amber	"	August 8. ..	September 5 ...	128
4	Kansas Orange...........	"	....	September 30...	153
5	Missouri Amber.....	"	August 8	September 5...	128
[illegible]	Bear Tail	"	August 8	September 5 ...	128
7	Link's Hybrid............	"	... .:...	September 30...	153
8	Honduras	"	August 26.....	October 7 ...	160
9	Hawmas.	"	August 8. ...	September 5 ...	128
10	Neeazana	"	August 8 ..	September 5 ...	128
11	White Mammoth.........	"	August 8.....	September 30...	153
12	Liberian...	"	.......?......	....?..... ..	....
13	Gray Top	"	....	September 30...	153
14	New Variety, Stump	"	August 8	September 5 .	128
15	Illinois Amber.....	"	August 8. . .	September 5....	128

ANALYSIS OF FIELD CROPS.

Variety.	Specific gravity.	Cane sugar.	Grape sugar.
Early Orange	1 059	10.30	2.71
Link's Hybrid	1 067	12 30	1 60
Liberian	1 060	10 70	2 95

Plot.	Date of planting.	Date of heading.	Date of hardening dough.	Days required.
1	April 20	Aug. 1	Aug. 31	131
2	"	"	"	131
3	April 20	"	"	124
4	"	"	"	124
5	May 26	Aug. 14	Sept. 16	112
6	"	"	"	112
7	"	"	"	112
8	"	"	"	112
9	"	"	"	112
10	"	Aug. 2	Aug. 31	96
11	"	Aug. 14	Sept. 16	112

ANALYSIS OF PLATS 1 TO 11.

	Plat.	Specific gravity.	Cane sugar.	Grape sugar.
Sept. 2	1	14 20	8 31	3 48
"	2	14 20	8 31	3 48
"	3	14 20	8 31	3 48
"	4	14 20	8 31	3 48
"	5	14.20	8.31	3 48
"	6	14 20	8 31	3 48
"	7	14 20	8 31	3 48
"	[illegible]	14 20	8.31	3 48
"	9	14 20	8 31	3 48
"	10	14 10	9 45	3 11
"	11	14 10	9 45	3 11
Oct. 21	1	1 070	11.55	1 74
"	10	1 074	12 55	1 52
	1	1 058	8 31	3 49
	*1	1 037	4 11	3 70
	6	14 6	7.80	4 80
	†6	17.2	12.62	2.58

* Stripped one week. † Topped while in blossom.

Professor Geo. H. Cook, director of the New Jersey Experiment Station, reports the following results of his analyses of several varieties of Sorghum in 1881:

The sorghum was grown on the college farm, and the chemical work carried out in the laboratory of the experiment station. The investigation includes the trial of different varieties of sorghum, with special reference to their time of ripening and percentage of sugar, as well as the study of the effect of different fertilizing ingredients, applied singly and in combination, upon the yield of sugar and seed.

The field selected for the experiment is thoroughly underdrained, rather heavy piece of land, cropped last year with field corn grown on sod, to which a liberal dressing of barn-yard manure had been applied. On that portion devoted to the trial of different varieties, Mape's sorghum manure was used this year immediately before planting, at the rate of 600 pounds per acre. The seeds were kindly furnished by Dr. Peter Collier, chemist of the United States Department of Agriculture.

Dr. Collier, in his valuable reports, has clearly shown that the condition of the ripening seed may be taken as an index to the condition of the juice of the plant. When the seeds have become so hard that they can no longer be split with the finger-nail, the stalks will contain the maximum amount of sugar and minimum of glucose, and when this stage is reached, the plant may be regarded as matured.

The importance of using great care in the choice of seed is illustrated by the following list of varieties:

Wolf Tail	Failed to mature before frost.
Link's Hybrid	do.
Liberian	do.
Early Amber	Seed failed to germinate.
Neeazana	Failed to mature before frost.
Goose Neck	Matured.
Sorghum	do.
Early Orange	Failed to mature before frost.
Oomseeana	Matured.
Gray Top	Failed to mature before frost.
African	Matured.
Honduras	Failed to mature before frost.
Chinese	do.
Early Golden	Matured.

Of the fourteen varieties, five only matured. Their relative value to the manufacturer is shown below:

	Goose Neck.	Sorghum.	Oomseeana.	African.	Early Golden.
Percentage of juice	60 3	61.4	58 8	57 5	60.0
Percentage of sugar in juice	8.58	7.28	6 50	7 60	14 06
Pounds of extractable sugar per ton	104	89	76	87	169

Professor Cook says that the Early Amber also matured, yielding, under favorable conditions, 162 pounds of sugar per ton of stripped and topped cane. Judging from this experiment, the choice of variety for this section of the State is limited to the *Early Amber* and *Early Golden*.

Professor Wiley, of the Indiana State University, reports the following analyses of sorghum juices, made in 1882:

ANALYSIS OF CANE JUICE OBTAINED FROM THE MILL OF THE LAFAYETTE SUGAR REFINERY.

No. of analysis.	Variety of cane.	Date of analysis.	Per ct. cane sugar.	Per ct. invert. sugar.	Sp. grav. of juice.	Total sugar.	Per cent albumenoids, gums, etc.	Remarks.
1	Amber	Oct. 8	7 23	4.76	1 0604	11 99	2 81	River bottom.
2	Orange	Oct. 9	9.02	4 23	1 0568	13 25	0 65	College Farm.
3	Orange	Oct. 9	8.76	4 34	1.0553	13.10	0 50	College Farm.
4	Amber	Oct. 11	8 00	3 40	1 0510	11.40	1.20	Second bottom.
5	Orange	Oct. 11	10.46	8 83	1 1630	14 29	1 11	
6	Amber	Oct. 12	8.39	4 88	1 0630	13 27	2 13	Clay upland.
7	Orange	Oct. 12	5.55	4 87	1 0630	10 42	4 98	
8	Amber	Oct. 13	7 85	6 06	1 0591	13 89	0 61	*
9	Orange	Oct. 13	8 74	5.09	1 0553	13.83	0 00	
10	Unknown	Oct. 14	7 80	2 96	1 0568	10 76	3.14	†
11	Orange	Oct 14	4 81	11 72	1 0669	16 03	0 27	
12	Amber	Oct. 14	7 84	5 54	1 0607	13 38	1.42	Kept 5 days in shed.
13	Orange	Oct. 14	2.63	13 57	1 0709	16 20	1 00	‡
14	Orange	Oct. 16	9 33	3 37	1.6529	12 70	0.40	
15	Amber	Oct. 21	5 79	6 61	1 0529	12 40	0 70	
16	Orange	Oct. 23	4.69	5 15	1 0453	9.84	1 36	
17	Unknown	Oct. 23	6 97	5 87	1.0510	12 84	0 00	
18	Amber	Oct. 23	9 21	4.01	1.0591	13 22	1.28	Very small and ripe.
19	Amber	Oct. 27	7 80	5 62	1.0607	13 42	1 48	Stood in shed 4 weeks.
20	Orange	Oct. 27	8 06	5 43	1 0591	13 49	1 01	Stood in shed 8 days.
21	Orange	Oct. 27	9 03	5 53	1 0665	14 55	1.65	Stood in shed 2 weeks.

* Upland. Sent in by car load, and stood over a week.
† Creek bottom, but cut and left in field 5 days.
‡ Cut and left in field 7 days; warm, rainy weather.

ANALYSIS OF JUICE OF SORGHUM, FROM AN EXPERIMENTAL FARM.

	Variety	Total weight of cane.	Rate per acre, in lbs.	Weight bagasse.	Per cent bagasse.	Per cent juice.	Per cent cane sugar in juice.	Per cent invert. sugar in juice.	Ratio of invert. to cane sugar.	Weight juice—Baume.	Specific gravity of juice.	Total per cent sugar of both kinds in juice.	Per cent water in juice.	Per cent albumenoids, chlorophyl, gums, etc.
1	White Liberian....	550	28149	185	33.7	66.3	7 00	4 27	1.64	7.50	1 0553	11 27	86 50	2.23
2*	White Liberian....	220	10542		..	..	11.00	4.67	2.36	8.00	1 0536	15 67	84 33	0 00
3	Miller.	350	17325	120	34.3	65 7	5 99	3.21	1.85	8.00	1 0586	9.14	85 50	5 36
[illegible]	Bear Tail	360	17820	130	36.1	63.9	6.00	3.75	1.60	7.75	1 0566	9 75	86.10	4.15
5	African	280	13860	..	...	..	6.67	6 06	1 10	8.00	1.0586	12 73	85.60	1.77
6	Goose Neck.......	320	15840	80	25	75	5 63	7.64	0 74	7.75	1.0566	13.27	86 20	0.53
7	Stump.	600	27000	208	34.7	65 3	5.04	5 37	0.94	8.00	1 0586	10 41	85.50	4.09
8	Neeazana.........	465	20925	188	41 7	58 3	10 48	6 11	1.71	9 50	1 0709	16.59	82 90	0 61
9	Honduras........	280	13860	78	27.8	72.2	6 95	5 80	1.20	7 00	1.0501	12.75	87.25	0.00
10	Honey	530	27125	203	38.3	61.7	6 64	6 11	1.08	7.50	1.0555	12 75	86 50	0.75
11	Link's.	335	18425	..	..	...	6 23	6.19	1 01	8 50	1 0626	12 41	84.70	2.89
12	White Mammoth..	275	15725	100	36.4	63 6	7.92	4.07	1 94	7.75	1 0566	11 99	86 20	1.51
13	Gray Top..........	605	29947	207	34.2	65 8	6 38	4 48	1 42	5.75	1 0645	10 86	83 18	4 96
14	Regular..	370	18936	148	40	60	8.92	4 28	2 09	8 00	1.0586	13 21	85 60	1.29
15†	Orange	1020	32500	335	32 5	67.5	6.69	5.28	1.27	8.75	1.0643	11.97	84.30	3 73

REMARKS.—Nos. 1, 2, and 3, lay in shed 4 days after cutting; Nos. 4. 5, 6, and 7, lay 5 or 6. All after this were worked within 3 or 4 days after cutting.

CHEMICAL COMPOSITION OF SORGHUM.

Professors Weber and Scovell give the following analysis of sorghum in their report:

Composition of stalks of Orange Cane in 100 parts:

Water.	76 58
Grape sugar.	3 00
Cane sugar.	9 77
Starch.	4 12
Fiber	4 54
Oil.	0 07
Gums and vegetable acids	0 24
Soluble albumenoids	0.23
Insoluble.	0 16
Soluble ash	0 68
Insoluble ash	0 06
	99.45

According to the above analysis it will be seen, that, if in the juice we include the water and soluble constituents, there would be present 91 per cent of juice, and 9 per cent of insoluble matter, starch, fiber, ash, etc. But it is well known that in pressing the cane a certain portion of these insoluble matters are mechanically removed, and go to increase the estimated amount of juice yielded by the mill, which is

* In this specimen, I think some was lost in taking to mill, or was mixed with some other variety.

† An average sample of what grew on a little more than four acres. The total yield of the field was sixty-five tons.

rarely as high as 60 per cent, often not over 45 per cent, of the weight of the stalk pressed. It is clear, therefore, that there is a loss of from one-third to one-half of the juice, and approximately the same loss of the sugar present in the cane.

The extent of this loss is such, that it will be more fully discussed in the chapter on "Waste products," page 376.

Character and Composition of Sorghum Juice—Chemical Changes in Sugar Making.

In order that the sugar boiler may understand the nature of this operation, and the character of the problem to be solved in defecation, as also to assist those who may desire to experiment for themselves in an effort to improve the present method, the following statement as to the character and chemical composition of the juice of sorghum is given, as also an account of certain of the chemical changes to which it is subject under certain conditions which naturally would exist in the ordinary operations of sugar making.

Sorghum Juice.

The juice expressed from the sorghum at or near maturity is a liquid containing quite a large amount of suspended matter, giving it a color varying from green to a deep brown. This suspended matter is deposited to a greater or less extent on standing, and consists of very fine starch granules, colored violet blue by iodine, and easily discolored by the acids of the juice, fiber, and albumen, with the green coloring matter of the outer portions of the stalk, and sometimes a red coloring matter from the center of the stalk.

After allowing it to settle a few minutes, it has a specific gravity of from 1.06 to 1.09, and contains in solution, in addition to the substances in suspension, most prominently sucrose, with smaller amounts of glucose, aconitic acid, soluble albumen, amide bodies, and inorganic salts. It can be freed from albumen, organic, and some inorganic acids, by means of basic acetate of lead—and this method of defecation is in use in most laboratories in the analytical determination of the content of sugar in the cane. The filtrate, after the addition of the acetate of lead, contains in addition to the sugars nothing which reduces Fehling's copper solution, with the exception possibly of a very small amount of amide substances.

The following examination of a juice collected on November 2nd, 1881, though somewhat late in the season and after a slight frost, will illustrate some points in the general composition:

WHITE LIBERIAN CANE JUICE.

Per cent of juice		65.00
Specific gravity		1.062
Total solids	per cent	15.67
Glucose	do	2.17
Sucrose by titration	do	9.79
Sucrose by polarization	do	9.15
Solids not sugar	do	3.51
Containing—		
Albumen	per cent	.13
Amido bodies, including ammonia salts	do	.37
Nitrate of potash	do	.01
Inorganic ash	do	1.12
Organic acids and fiber	do	1.90

The inorganic part of the juice consists of soluble silica, iron, lime, magnesia, potash, phosphates, sulphates, chlorides, nitrates.

All attempts to detect gum or any carbo-hydrates other than glucose and sucrose in the juice, before it has changed its character by standing, have failed.

After the juice has been left to itself, with or without the addition of ferments, it undergoes certain changes.

In the first place, it deposits a white substance which, under the microscope, shows the organized structure of starch. The granules are, however, much smaller than most starches, and do not give as deep a blue color with iodine, the color fading out in a short time. On longer standing, there collects a greenish precipitate on the surface of the starch, containing fiber, albumen, and coloring matter. The supernatant liquor, however, never becomes entirely clear.

During the course of from twenty-four to forty-eight hours in warm weather fermentation sets in, even with no addition of yeast. The products are not strictly those of the vinous fermentation, neither are they entirely like the lactic. Much lactic acid is, however, formed, together with a large amount of mannite and a smaller amount of alcohol, acetic acid, glycerine, and succinic acid. The same thing takes place even when quite large quantities of yeast have been added to the juice.

If the juice immediately on extraction is filtered through paper and allowed to stand, the cellulosic fermentation sets in, and over night white clots of cellulose, or a similar substance, settle out on the walls of the containing vessel. What the products in solution are, under these circumstances, has not been investigated. If the expressed juice is immediately mixed with numerous slices of fresh cane and left to itself, lactic fermentation is probably the form to be expected. The same form of fermentation always occurs on adding slices of cane to a pure sugar solution. If, however, to the juice sufficient slices of cane are added to fill the vessel as nearly as possible with them, then the mucous fermentation takes place. After a few days the liquid becomes sticky, and alcohol precipitates from it a ropy slime, not easily soluble in water, and resembling the gum found in many sorghum syrups.

The Acidity of Corn and Sorghum Juices.

The juices of four varieties of sorghum and two of corn have been examined at various intervals during the growth of the canes to determine their acidity, and with the result presented in the following tables.

While it is impossible to draw any very definite general conclusions, owing to the great irregularity in the amount of acid present in juices expressed from canes in the same stage of development, it is apparent that in all but one of the varieties which have been examined, there is a greater amount of free acid in the juice during the later stages of growth. Two of the sorghums show besides an apparent decrease to about the eighth or ninth stage, followed by an increase later on in the development of the canes. Beyond these conclusions it is impossible to go.

The determinations were made in the following manner:

The method employed for the volumetric determination of the acid present in sorghum or maize stalk juice was as follows:

50 c. c. of the juice, usually of a greenish or greenish brown color, was titrated with a fiftieth normal solution of sodium hydrate $\left(\frac{n}{50}\mathrm{NaOH}\right)$.

The acid was calculated as malic acid$=(H_2C_4H_4O_5)$.

1 c. c. of $\frac{n}{50}$HNaO$=$ .00134 malic acid.

As the most practical indicator for the final test of saturation of the acid juice by soda solution, a dilute solution of extract of logwood was used, which, when added to the juice containing a slight excess of NaOH, turned to a bluish purple or violet color. This final reaction was made in small porcelain dishes, into which a few drops of juice were brought and some drops of logwood added by means of a glass rod. Before this point of neutrality was reached, red and blue litmus paper was employed.

The calculation was as follows:

A sample of sorghum juice, 50 c. c. required—

1. 44 c. c. of $\frac{n}{50}$HNaO solution for saturation; hence 100 c. c. of juice $44\times2=88.0$.

2. $88\times.00134$ (malic acid)$=$ .11792.

3. $\frac{.11792 \text{ (malic acid)}}{1.0660 \text{ (specific grav. of juice)}}=$ .11051 gram of malic acid in 100 grams of juice.

SORGHUM JUICE ACIDITY.

Early Amber.

DATE.	Stage.*	c. c. of $\frac{n}{50}$HNaO for 100 c. c. of juice.	Specific gravity of juice.	Per cent of acid as malic.
July 23	7	96	1 041	.123
July 25	9	100	1.047	.128
July 25	9	120	1 049	.153
July 28	9	124	1 053	.158
July 29	10	96	1.058	.121
Aug. 1	11	120	1.066	.151
Aug. 8	12	156	1 072	.195
Aug. 24	15	196	1.083	.242
Aug. 26	15	192	1 080	.238
Aug. 27	15	156	1 091	.192
Aug. 31	16	136	1 091	.167
Sept. 3	17	160	1.091	.196
Sept. 7	17	192	1 089	.236
Sept. 10	18	196	1 081	.243
Sept. 17	18	236	1 088	.291

Golden Syrup.

DATE.	Stage.	c. c. of $\frac{n}{50}$HNaO for 100 c. c. of juice.	Specific gravity of juice.	Per cent of acid as malic.
July 27	10	132	1.039	.170
Aug. 1	11	156	1 073	.195
Aug. 8	12	160	1.075	.200
Aug. 19	14	184	1 083	.228
Aug. 24	15	152	1 085	.188
Aug. 26	15	196	1 086	.239
Aug. 29	16	172	1 079	.213
Aug. 31	16	192	1 089	.236
Sept. 3	17	164	1 091	.201
Sept. 7	17	180	1 095	.220
Sept. 17	18	252	1 087	.311

* For explanation of "stage," see page 119.

Wolf Tail.

DATE.	Stage.	c. c. of $\frac{n}{50}$ HNaO for 100 c. c. of juice.	Specific gravity of juice.	Per cent of acid as malic.
July 21	3	128	1 043	.164
July 28	4	120	1 042	.154
July 29	5	122	1 049	.156
July 30	6	84	1 053.	.107
Aug. 1	5	92	1 054	.117
Aug. 10	8	88	1.066	.111
Aug. 16	9	120	1 077	.149
Aug. 20	9	88	1 065	.111
Aug. 25	10	108	1.078	.134
Aug. 30	11	156	1.086	.155
Sept. 1	12	120	1 087	.148
Sept. 5	13	152	1 084	.189
Sept. 9	14	148	1 094	.181
Sept. 14	15	152	1.090	.187
Sept. 27	......	156	1.086	.192

Oomseeana.

Date.	Stage.	c.c. of $\frac{n}{50}$ HNaO for 100 c. c. of juice.	Specific gravity of juice.	Per cent of acid as malic.
July 28	1	132	1 032	.171
Aug. 2	1	• 64	1.035	.083
Aug. 11	2	92	1 045	.118
Aug. 11	3	80	1 044	.103
Aug. 11	4	92	1.043	.118
Aug. 16	5	72	1.055	.091
Aug. 16	6	62	1 055	.079
Aug. 21	7	80	1.062	.101
Aug. 26	8	80	1 061	.101
Aug. 30	9	100	1.072	.125
Sept. 2	10	96	1 075	.119
Sept. 5	11	100	1.073	.125
Sept. 9	12	68	1 065	084
Sept. 15	13	152	1.076	.190
Sept. 27	......	160	1,072	.200

Composition of Ash of Canes and Juices of Sorghum.

The actual composition of the pure ash, both of the whole cane and the expressed juice, are matters of interest and importance. From a careful study of the following figures, it will be seen that the amount of potash extracted from the soil, is much greater than the amount of any other ash ingredient, while the quantity of phosphoric acid is small. It would seem, then, that the farmer should supply these two constituents, when his soil seems to need them, in about the relative proportions in which they exist in the ash. The following are analyses of two lots of ash from sorghum, and two samples of ash from sorghum juices:

*ANALYSES OF ASH FROM SORGHUM CANES AND JUICES.

Constituents.	Canes.			Juices.	
	No. 1.	No. 2.	No. 3.	No. 1.	No. 2.
Potash, K_2O	49 66	33.77	46.48	†55.31	†54.76
Potassium, K	4 31	14.58	.00	....	....
Sodium, Na	....	....	.90	Trace	.07
Lime, CaO	13.49	9 00	6.82	7 20	7.40
Magnesia, MgO	10 47	10.28	4.64	6 36	7 85
Iron Oxide, Fe_2O_3	....	....	.14	2 01	1.63
Silica, SiO_2	8 97	2.93	27 91	6 31	2.57
Sulphuric acid, SO_3	5.55	11.70	6.23	5 11	4.11
Phosphoric acid, P_2O_5	3 64	4.50	5 37	8 22	5 72
Chlorine, Cl	3.91	13.24	.25	9 08	15.89
Manganese Oxide	....	....	.89	....	....
	100 00	100.00	99.63	100.00	100.00

* Analyses Nos. 1 and 2 of canes and juices, were made at the Department of Agriculture. Cane Analysis No. 3 is reported by Professors Weber and Scovell, of Illinois Industrial University.

† It was thought best in these analyses, to state all the potassium as oxide, although, doubtless, a part existed in the juice in combination with chlorine.

CHAPTER VIII.

(*a.*) Extraction of juice from cane.
(*b.*) Roll mills.
(*c.*) Various methods for the extraction of juice.

EXTRACTION OF JUICE FROM CANE.

In the production of sugar from plants, the first step is the extraction of the juice; and in this operation the methods generally applied to sugar-cane and sorgum or maize stalks, on the one hand, and to beets upon the other, differ radically, and those methods employed with beets are in their principles and in their results vastly superior to those in general use in the production of sugar from cane.

A recent writer, eminently qualified from long experience to judge of these matters, declares that "the sugar beet industry in all its details has been so exhaustively investigated, in Europe, that it may, without exaggeration, be declared to be at present the most thoroughly developed department in the whole range of industrial science. The question of the successful introduction of this industry into the United States rests on purely economic considerations."

In no respect is the perfection to which this industry has been brought more manifest than in the success which attends the processes for the extraction of the juice from the beets, and in no respect are the two methods of sugar production from cane and beets more at variance than in this preliminary step in manufacture.

A glance at the results obtained will suffice to show how much yet remains to be done before the sugar-cane industry shall even approach in practical economy that of the sugar beet.

The results ordinarily obtained in making beet sugar are as follows: 100 pounds of beet roots give—

First sugars	5.00	pounds.
Second "	1.50	"
Third "	.50	"
Molasses	1.50	"
Loss. Sugar in pulp	.50	"
" " " scum	.35	"
" " " filters,	.59	"
" Miscellaneous	.06	"
Total	10.00	pounds.

The above estimate is from "Sugar Growing and Refining," page 387.

With beets of higher sugar content than 10 per cent, the losses

would be proportionately less, and *vice versa;* but it will be seen that only 5 per cent of the total sugar of the beet is lost in the pulp, while the amount of sugar ordinarily lost in the bagasse of sugar-cane or sorghum is fully one-third of the total amount present in the canes.

This amazing loss, a loss which aggregates at least $100,000,000 worth of sugar annually, is due entirely to the imperfect extraction of the juice by the ordinary cane mill.

In the main, the principle of extraction has suffered no change for centuries. The most elaborate and expensive mills of the sugar plantations of Cuba, capable of crushing hundreds of tons of cane daily, are but modifications of the primitive mills of centuries ago, when, with greater labor and greater loss, a few armsful of cane was the daily capacity of the rude and inexpensive mill.

In the hope that the skill and ingenuity, which has satisfactorily solved so many practical problems which have hindered the full development of many new industries, may be also successfully applied to this, it is well to consider briefly the nature of the problem to be solved.

This problem—the complete extraction of the sugar from the plant—is by no means beyond hope of satisfactory solution. It is now brought to the attention of a new class of people, proverbially clever and full of invention, and fortunate in this, that, with a full knowledge of its conditions, they are largely free from the prejudices of long established methods, the practical knowledge of which is likely to retard rather than stimulate invention.

To such a class was the extraction of sugar from beets presented, and, although a comparatively new industry, it has been from its infancy, and to-day is exclusively, in the fostering hands of science, and, as an industry, is fully abreast of the most advanced science of the day. It is to this that the beet is entirely indebted for its success in having become the only rival practically of the sugar-cane in the production of sugar. When but a fraction of the attention which has so far advanced the beet sugar industry shall have been given to sorghum, there can be no doubt but that it will speedily become to us as a people the most profitable and economical source of our sugar supply.

Structure of the Cane.

The stalks of sugar-cane and of sorghum, when mature, very closely resemble each other in their general character. The stalk of sorghum consists of a solid stem, from $\frac{3}{4}$ to $1\frac{1}{2}$ inches in diameter, and from 6 to 12 feet long, according to the variety, separated into joints from 6 to 10 inches apart. These joints are nearer together at the butt end

of the stalk than at the upper portion. At each joint a leaf develops alternately upon the side of the stalk, and, as the plant matures, those leaves at the lower parts of the stalk gradually die. The leaves partly enwrap the stalk, and then fall away in blades from 2 to 4 inches in breadth, and from 2 to 3 feet in length. The stalk terminates in a panicle (seed head), which is diffuse and spreading, or close and compact, with seeds varying from brown to white, according to variety.

By cutting across the stalk between the joints, and treating with a solution of iodine, there are seen to exist numerous large fibers, about each of which are clustered small cells of nitrogenous material, with intermediate cells of ordinary cellular tissue, containing the sugar in solution. By splitting the stalk lengthwise through the joint, there is shown, upon the application of iodine, a belt of highly nitrogenized tissue, about one-eighth to three-sixteenth of an inch in width, while distributed along the portion of the stalk between the joints the blue grains of starch appear. The exterior of the stalk is composed of more compacted fibers of woody matter, enveloped in a hard siliceous covering, much resembling the sugar-cane, but less hard. Like the sugar-cane, a slight coating of a waxy substance (cerosie) covers the stalk, especially at the joints. Except that the joints are not so close on the sorghum, and that the stalk is softer in its structure and generally less in diameter than the sugar-cane, the resemblance of the stripped stalks of these two plants is very close.

Owing to the fact, that the water present in the juice of the plant is always far in excess of the amount necessary to hold the sugar in solution, there is no reason to be seen that the sugar is ever present in the fresh cane in a solid form, as has sometimes been asserted. By means of diffusion, the contents of the cells readily pass from one portion to another of the plant; and during the life of the plant this circulation is constantly going on, such matters of the juice as are necessary being supplied to the growing parts, while the sugar, which is being elaborated in the leaf cells, is accumulated in the cellular tissue of the stalk, gradually increasing in quantity as the plant approaches maturity.

Mills for Extracting Juice.

The principle of nearly every mill for the extraction of juice from cane or sorghum, at present in use, depends upon rupturing the cells of the cane by pressure, and in this way expressing the juice. In certain mills this pressure is estimated as equal to 1,200 pounds to the square inch, or a pressure upon the entire roller of 300 tons. This pressure is generally produced by three rolls—one upper and two lower—the cane passing first between the upper and one of the lower

rollers; and then, by assistance of a returning bar, or knife, as it is termed, the partially crushed cane again passes between the upper and second lower roller. The mills may be classed as upright, or horizontal, according to the position of the rolls. All mills of large size are with horizontal rollers. They are also two, three, and four roll mills, generally three.

In the case of four rolls being used, it is customary to separate them, and, by means of a jet of steam or water, to moisten the partially expressed cane before subjecting it to pressure between the second pair.

In the construction of mills upon this general principle, it is doubtful whether there is left much, if any, room for improvement. The amount of juice expressed varies from 45 to 65 per cent of the weight of the stripped cane, and in exceptional cases, where, as in competition trial of mills, every precaution is taken, the amount of juice may reach 70 per cent, but it is doubtful whether the average results will equal 60 per cent of juice extracted by the sugar mills.

We have seen that the average of juice present in the cane is at least 90 per cent of its weight; and there is reason, therefore, to consider the principle of these mills, to learn whether such waste of juice is necessary and inevitable in their use. It appears that such loss is inevitable, owing to the following reasons:

1. The cells of the cane, which contain the juice, are microscopic in size, and many of them escape rupture, even under the enormous pressure to which the cane is subjected, and it is not unlikely (though, perhaps, this can not be experimentally determined) that the elasticity of the cell walls is such, as to permit a certain degree of pressure before they are ruptured.

2. Owing to capillarity, the bagasse (or pressed cane) rapidly absorbs the juice the instant the pressure is removed; and, since a portion of the juice will follow the cane through the rolls, such portion is at once taken up by the bagasse. It is, of course, mathematically true, that the maximum of pressure exerted, even with the largest rolls and with the slowest revolution, is but instantaneous; and, as the escape of the juice can not be as rapid, a large share of it must be lost. In fact, such is found to be the case. Although, in common language, we often hear the bagasse spoken of as "perfectly dry," it is never found with less than half its weight of water, even after having come from the best mills; and generally it will be found, that the percentage of water still remaining in the bagasse is equal, approximately, to that present in the cane before it was pressed. With this water is, of course, a large amount of sugar, estimated as being equal to the half of that expressed in the juice.

ROLL MILLS.

The following illustrations will show the different styles of mills at present in use in the United States, adapted for horse, water, or steam power. It is always advisable to have a mill at least a size larger than appears to be necessary for the remaining apparatus, since the supply of juice, for continuous work, must be maintained, and any excess may be easily avoided. It is also a matter of economy to secure the strongest mill of any given capacity; for any break down may so interrupt the work of the season as to imperil the entire crop. It is desirable, also, that the power applied be in excess of what is really demanded for regular work, since it often happens, through improper feeding, that there is danger of choking the mill, and thus causing delay, if not breakage of some of the parts.

The object of the illustrations of mills, is to enable the farmer to see their general character. Those who may desire mills of larger capacity than these represented, need only to be informed that they may be secured of any capacity up to several hundred tons daily, and are, in all respects, identical with those in use upon the large sugar plantations of Cuba and Louisiana.

These illustrations are inserted solely for the purpose of information to the reader, and not as advertisements of those who have kindly furnished the plates for use. There are, doubtless, other manufacturers of mills and other apparatus similar to these represented in this volume, but whose models do not appear. The general fact, however, is one that should be had in mind, viz.: that it is true economy to buy a mill of somewhat greater capacity than that which is thought necessary; also, that extra weight and extra strength will far more than compensate for a little additional cost.

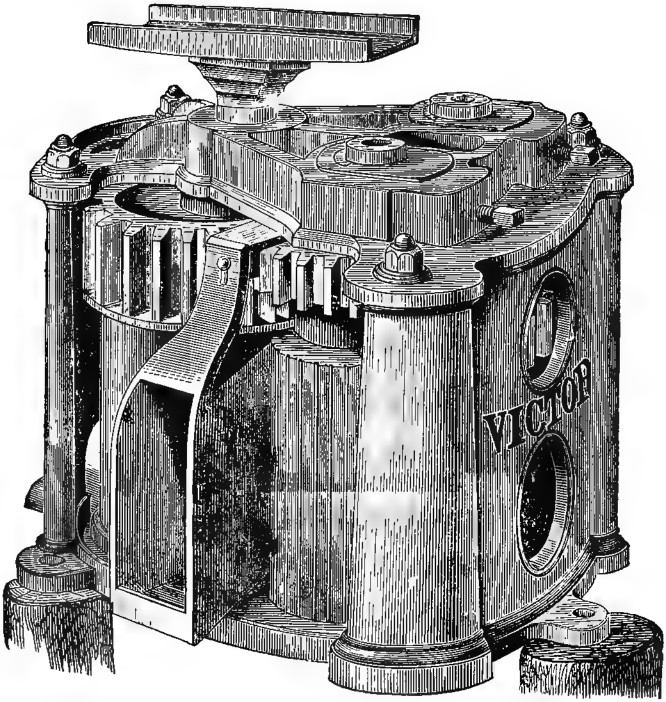


Plate XXII.

Plate XXII. shows the Victor Cane Mill, an apparatus in very common use. It is constructed with vertical rollers, on a plan suited to horse-power, or with horizontal rollers for water or steam power. The horizontal mills are fitted with extra gearing, are necessarily heavier, and require greater motive power to accomplish the same result.

The following list of sizes and capacity of mills, of this style, will be of value. These mills are made by Blymyer & Co., Cincinnati, Ohio :

Size.	Weight.	Tons cane in 12 hours.	Acres cane per season.
No. 0, Light One-horse......... ...	390 lbs.	2 to 2½	5 to 8
No. 1, Jr., One-horse...............	550 "	2½ to 3	7 to 10
No. 1, Heavy One-horse.....	750 "	3 to 3½	8 to 12
No. 2, Two-horse...................	875 "	4 to 5	12 to 18
No. 3, Heavy Two-horse..	12,00 "	6 to 7	20 to 30
No. 4, Large Two-horse	1,300 "	8 to 9	25 to 35
No. 6, Four-horse	1,800 "	11 to 13	35 to 45

The same mill, with the sweep below, is furnished by the same parties. For many, such a mill is greatly to be preferred, since it permits full access to the mill for bringing cane, removing bagasse, and it may be used in the second story of any suitable building.

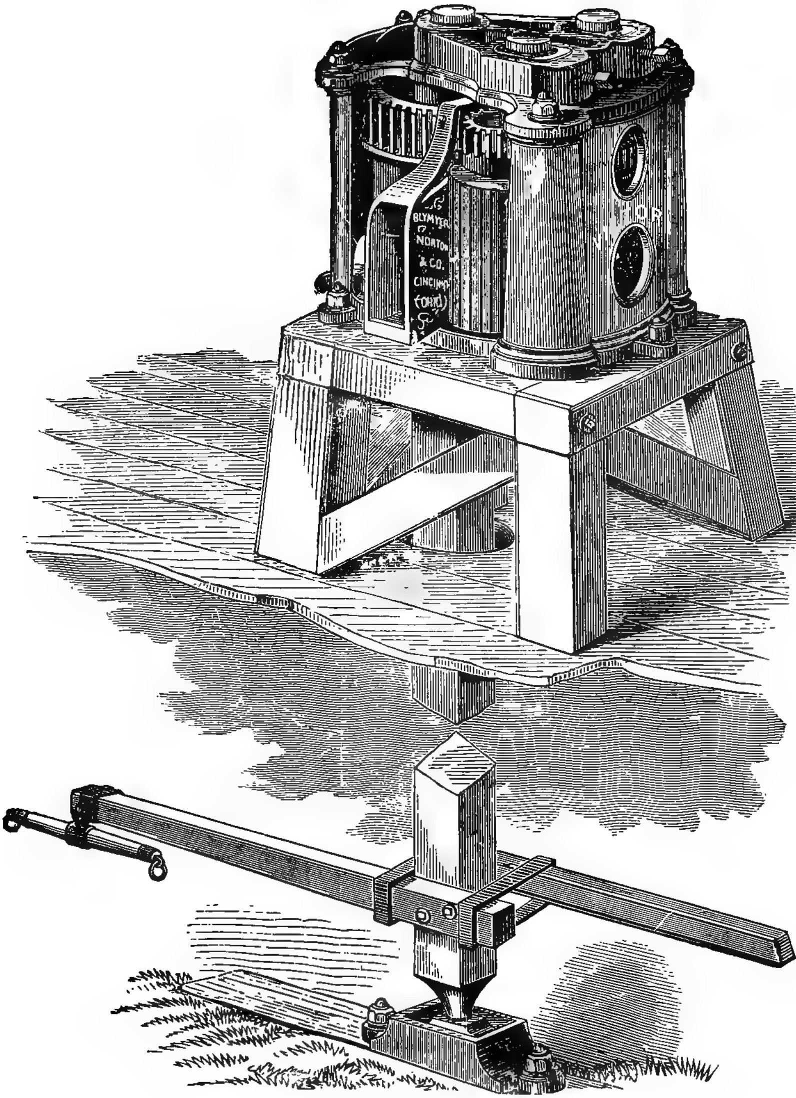


Plate XXIII.

VERTICAL VICTOR MILL.

[With horse-power below.]

The mill with sweep, shown above, presents these advantages over the common Victor mill: 1. The mill is more steady. 2. The horses do not interfere with bringing cane to the mill, feeding or removing the bagasse. 3. The juice can flow, by gravity, to the juice tank and defecation, on lower level, thus avoiding pumping.

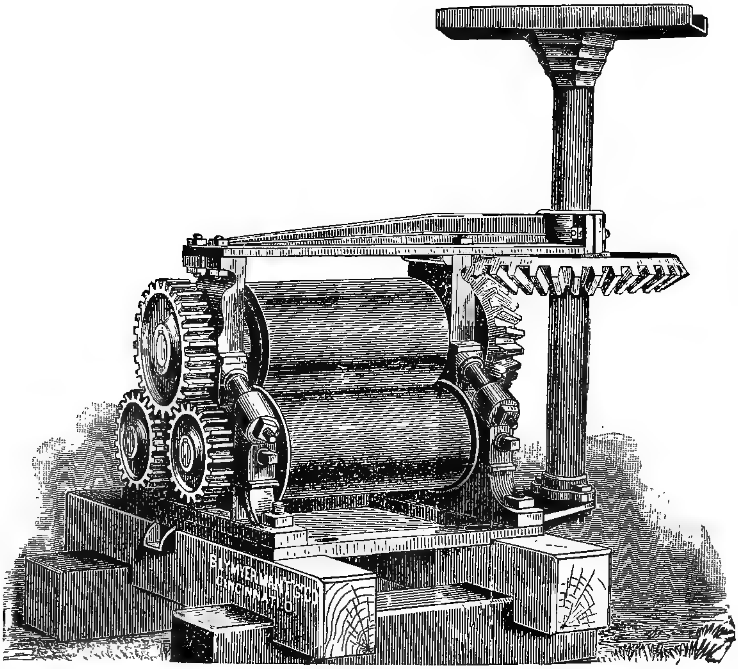


Plate XXIV.

HORIZONTAL MILL.

The above represents a good form of a mill, adapted to horse-power, and with horizontal rolls. The size, capacity, weight, and price list of these is as follows:

Power.	Size of rollers.		Weight.
No. 1—2 to 4 horse.	1—15 x 12.	2—15 x 9.	2,100 lbs.
No. 2—4 to 6 "	1—20 x 12½.	2—20 x 9½.	2,400 lbs.

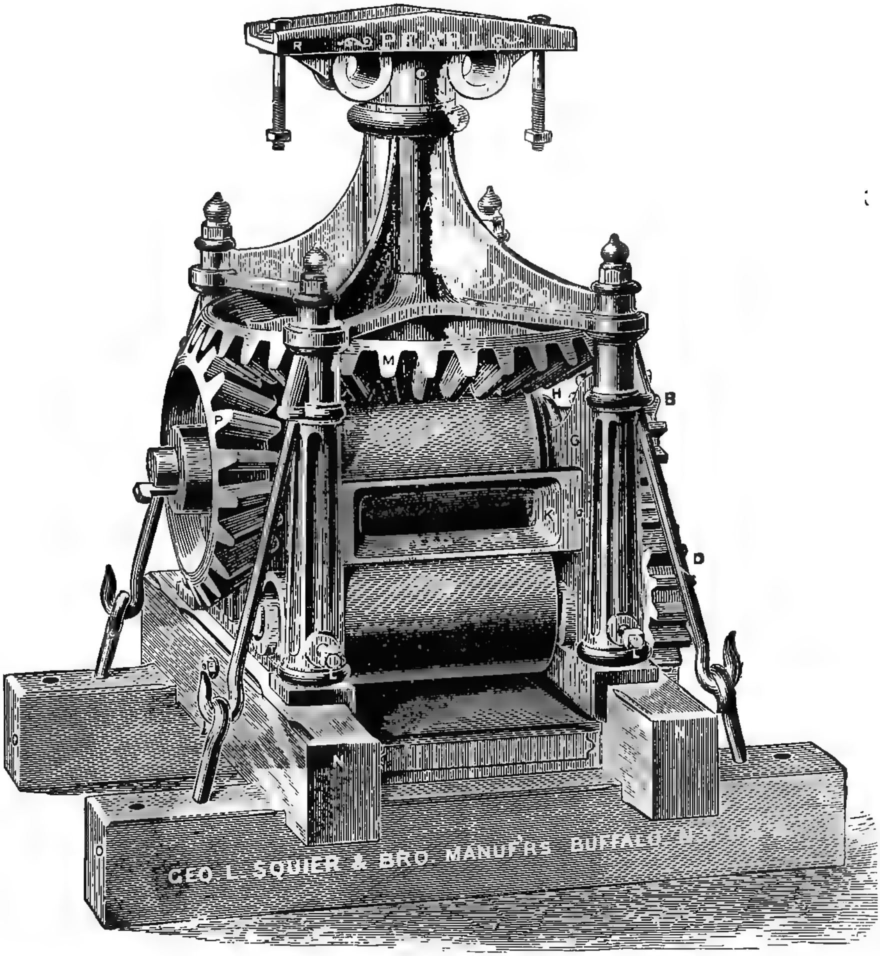


Plate XXV.

HORIZONTAL, SELF-ADJUSTING ANIMAL-POWER MILL.

The above plate represents a horse-power, horizontal roll mill, made by Geo. L. Squier, Buffalo, N. Y. The following list of sizes and weights are given:

Pearl No. 1.	Main Roller, 8 x 8.	Weight, about 800 lbs.
Pearl No. 2.	Main Roller, 10 x 10.	Weight, about 1,200 lbs.
Pearl No. 3.	Main Roller, 10 x 12.	Weight, about 1,400 lbs.
Pearl No. 4.	Main Roller, 12 x 16.	Weight, about 3,000 lbs.

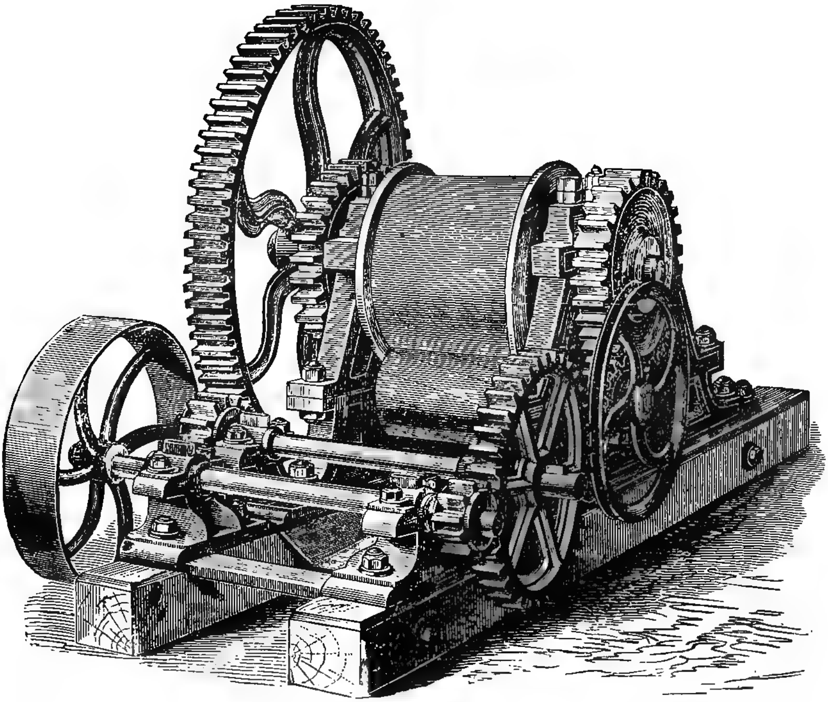


Plate XXVI.

The Horizontal Victor, illustrated in above cut, has the plan of dispensing with the return plate between the rolls. These mills have three rolls, and are made extra heavy and strong. A Bagasse Carrier, 10 to 15 feet long, is furnished, and is included in the prices given of the mills.

Size.		Tons Cane in 24 hours.	Acres Cane per season.	Weight.
No. 0, four	horse,	16 to 20 tons,	50 to 60 acres.	2,300 lbs.
No. 1, six	"	24 to 30 tons,	60 to 80 acres.	3,200 lbs.
No. 2, eight	"	30 to 40 tons,	70 to 90 acres.	3,600 lbs.
No. 3, ten	"	40 to 50 tons,	80 to 100 acres.	4,000 lbs.
No. 4, fifteen	"	70 to 90 tons,	250 to 300 acres.	10,000 lbs.

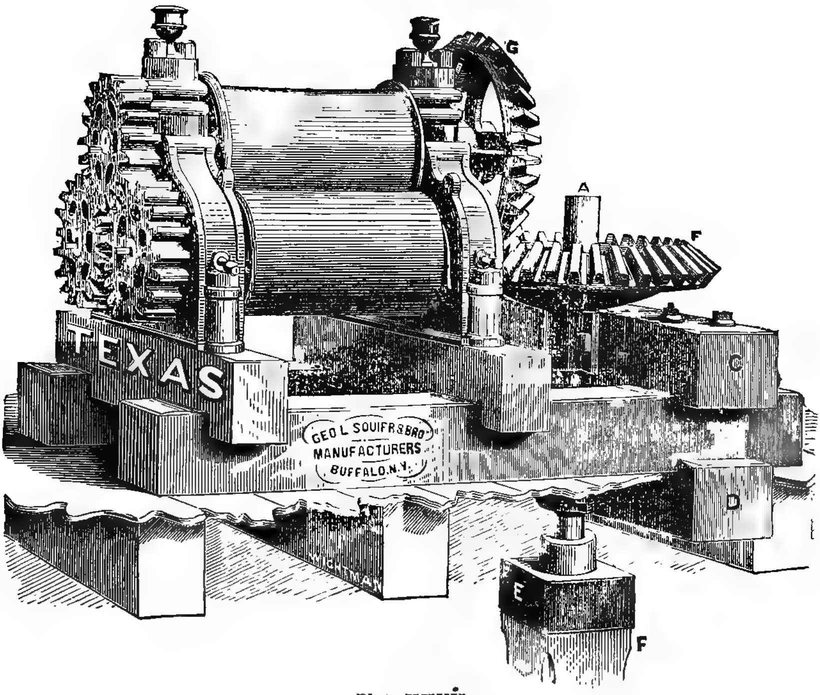


Plate XXVII.

HEAVY HORIZONTAL HORSE-POWER MILLS, WITH SWEEP BELOW OR SWEEP ABOVE, AS DESIRED. FIVE SIZES.

There are many advantages in a Sweep Below Mill, when the planter has a proper building in which to run it. The mill is placed in the second story of the building, and a shaft extends from thence to the ground, to which the team working on the ground floor is attached. The team and sweeps are entirely out of the way of the mill; the cane can be unloaded from the cart directly into the second story of the building, and piled near the mill under cover; the bagasse can be carried by a shute into the cart and carted off, and the juice spouted to the defecator or evaporator, without lifting or pumping. A Feed Table or Cane Carrier can be used with the mill as described.

Texas No. 0.	Main Roller, 12 x 15.	Weight, 2,000 lbs.
Texas No. 1.	Rollers, 12 x 20.	Weight, 3,500 lbs.
Texas No. 2.	Rollers, 12 x 20.	Weight, 4,100 lbs.
Texas No. 3.	Rollers, 16 x 24.	Weight, 6,600 lbs.
Texas No. 4.	Rollers, 20 x 30.	Weight, 13,150 lbs.

The above mill, Plate XXVII, is made by George L. Squier, Buffalo, N. Y.

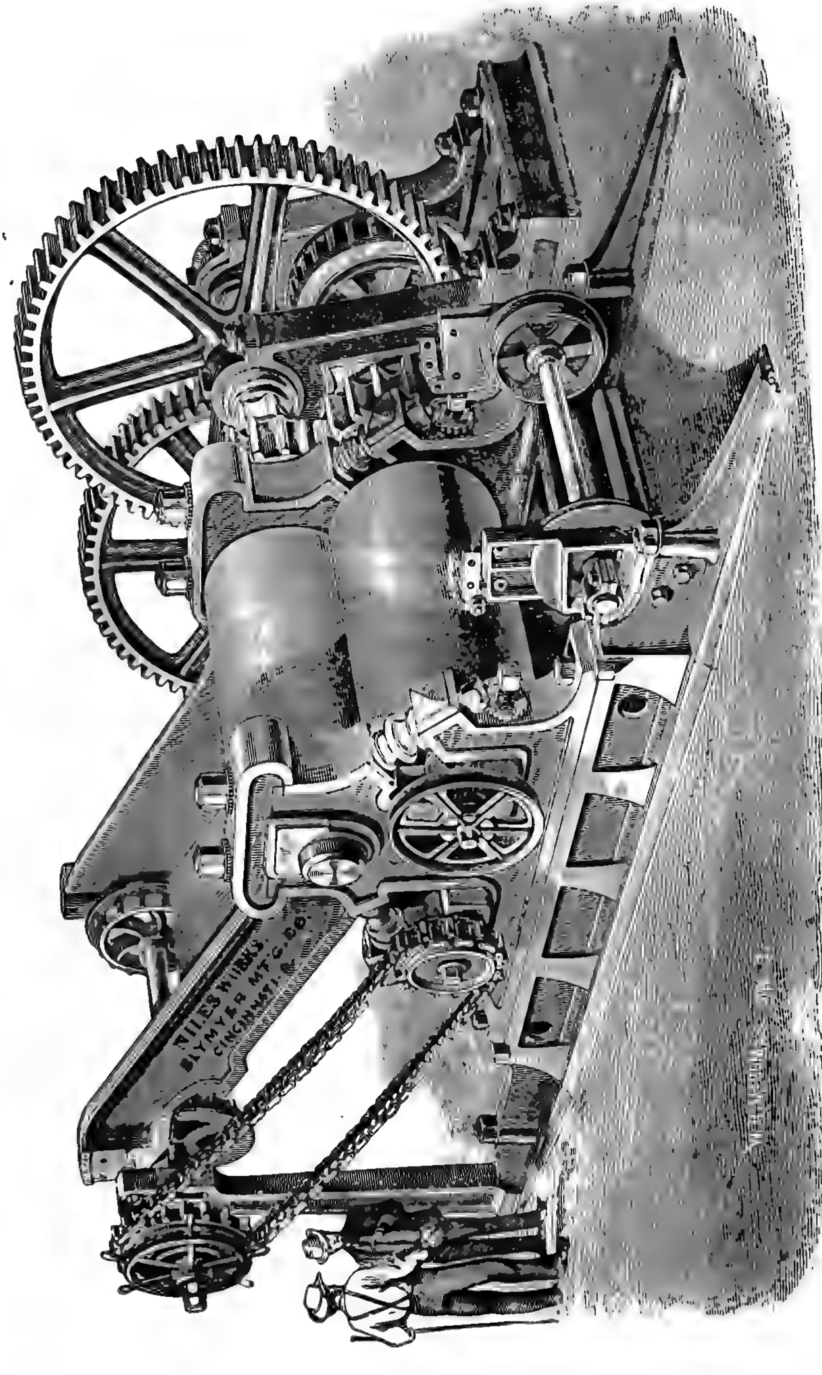


Plate XXVIII.

The engraving, Plate XXVIII, represents the Niles Three Roll Cane Mill, which is in very general use upon the sugar plantations of Louisiana.

The following lists of sizes and weights, will be of interest to those wishing to buy.

They are manufactured by Blymyer and Co., Cincinnati, Ohio, U. S. A.

Size. Number.	Length and Diameter of Rolls.	Weight.	Size. Number.	Length and Diameter of Rolls.	Weight.
3	16 in. x 16 in.	7,200 lbs.	13	54 in. x 26 in.	52,000 lbs.
4	20 in. x 16 in.	8,500 lbs.	14	54 in. x 28 in.	56,000 lbs.
5	24 in. x 16 in.	10,200 lbs.	15	60 in. x 28 in.	63,500 lbs.
6	24 in. x 20 in.	20,500 lbs.	16	54 in. x 30 in.	75,000 lbs.
7	30 in. x 20 in.	22,000 lbs.	17	60 in. x 30 in.	80,500 lbs.
8	36 in. x 20 in.	30,000 lbs.	18	66 in. x 30 in.	82,500 lbs.
9	36 in. x 24 in.	35,000 lbs.	19	72 in. x 30 in.	97,000 lbs.
10	42 in. x 24 in.	38,000 lbs.	20	60 in. x 34 in.	120,000 lbs.
11	48 in. x 24 in.	41,000 lbs.	21	66 in. x 34 in.	130,000 lbs.
12	48 in. x 26 in.	47,000 lbs.	22	72 in. x 34 in.	140,000 lbs.

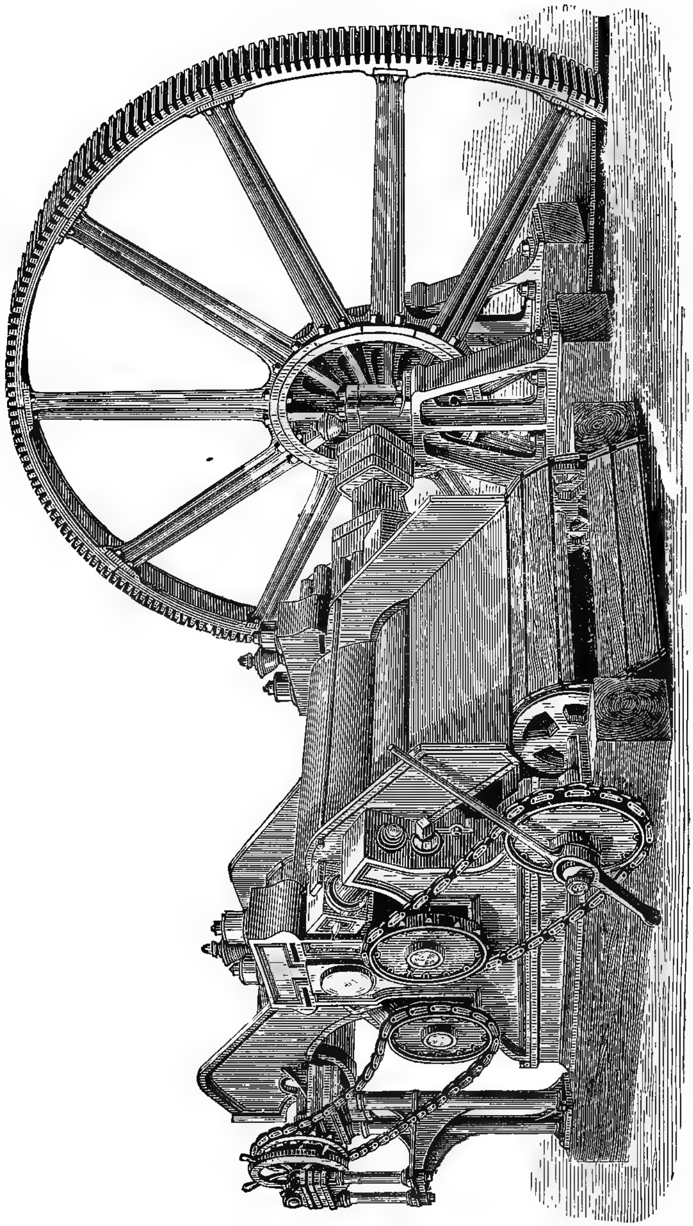


Plate XXIX.

Plate XXIX represents a plan of cane mill, showing the three rolls, cheek pieces, cane and trash carrier pulleys; also, how they are actuated by the geared wheels by a linked iron belt.

The mill as shown represents a single-geared mill—that is, the pinion is connected directly on the main shaft of engine, and operates into the main wheel, secured to the shaft of the top roll. A better way is to make it compound geared, speeding it so that a point on the surface of the roll will travel about fifteen feet per minute, and the engine about thirty revolutions to one of the mill.

The top roll is arranged in connection with a knife, so as to direct the cane toward the center of the bagasse side, and by this, hindering it from passing out between the ends of the rolls and dropping into the juice pan, which is placed between the cheeks so as to catch the juice as it falls.

The cane carrier is a long traveling table of ash slats, as wide as the rolls, secured at each end in the long links of a chain, and passing over the inboard pulleys, which have projections to catch into the short links of the chain. The outboard pulleys and shaft are plain, and secured to a suitable foundation. This carrier is set in action by means of a chain belt, receiving its motion from the cane roll, the shaft of it being longer on this end to receive the wheel. If the cane carrier should be too much loaded, so as to crowd the mill, the carrier can be stopped by means of the lever V, which throws out the noiseless friction clutch, allowing the carrier to be idle while the mill revolves and clears itself.

The deliverer, or trash carrier, is arranged in the same manner, but has no need of the stop motion, as the trash can be carted away as fast as made.

We are now making mills with steel shafts, crown wheels, and pinions—much stronger than wrought or cast iron.

There is also arranged, in connection with the mill, a juice tank and plunger pump, operated from one of the shafts by means of a crank, and of capacity about double what could be anticipated of the mill, in order that it may never choke.

This mill is manufactured by Colwell Iron Works, New York, and of any size desired.

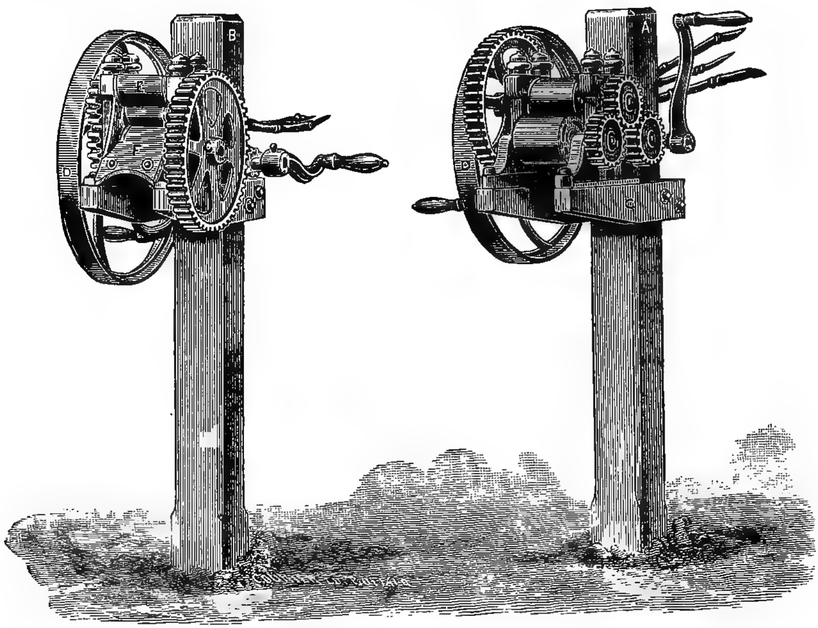


Plate XXX.

To those engaged in the examination of canes, whether of sorghum, maize, or sugar-cane, it is of the greatest importance to have at hand a small mill, by which the juice of a single stalk may be obtained for examination.

To the planter who desires to learn the condition of his crop, such a mill is almost indispensable. The above plates represent mills of this discription made by George L. Squier, Buffalo, N. Y. The weight of the mills is from 170 to 270 pounds, and the rolls are from 4 inches long and 4 inches in diameter, to 5 inches long and 5 inches in diameter, and are said to give a yield of juice fully equal to the large mills.

Importance of a good Mill.

It is most desirable, in order to secure the best results possible, that great care be exercised in the selection of a mill, since there is, even with the best mill, a very considerable amount of sugar left in the bagasse. According to the testimony of an experienced sugar chemist and engineer, it is probably true that nearly, if not one-half, of the sugar present in the cane of Louisiana is left in the bagasse, for he says:

To a great many it may appear startling, that about 50 per cent of the sugar

is left in the cane after it passes through the ordinary mill. Some who doubt this base their opinion on the apparent dryness of ordinary bagasse, while others arrive at their conclusions from experiments which, from their nature, are fallacious. The fallacy lies in the high percentage of juice claimed for the mills. It is probably quite correct that, by taking a few hundred, or even a few thousand, pounds of cane, and passing them carefully through a good mill, such high percentages may be secured; but, with the average mill, grinding in the ordinary way, I have reason to believe that the percentage of juice obtained, on the whole weight of the cane, is more frequently under fifty than over.

The above estimate of loss is undoubtedly too high, but all are agreed that there is a very great loss in this operation of expressing the juice.

To illustrate this more fully, let us take the average results of the analyses made in 1881 of the sorghums during those three periods when the best results in sugar were found.

The average composition of the juices at this time was as follows, and it must remembered that these canes were passed singly through a mill, giving, as will be seen, excellent results in juice:

	Per cent.
Juice expressed	58 57
Sucrose in juice	16.18
Glucose in juice	1 83
Solids in juice	3.07

But 21.08 per cent of the juice, the amount of total solids, is 12.35, which, subtracted from the percentage of juice, leaves 46.22 per cent, as the amount of water expressed in the juice.

Now, the amount of water actually present in the cane at this period is probably not less than 75 per cent, which would leave in the bagasse 28.78 per cent of the weight of the cane as water; and, since the bagasse constitutes 41.43 per cent of the weight of the cane, there would still remain in the bagasse 69.47 per cent of its weight of water. This, to the ordinary observer, would appear incredible, since the bagasse is so generally spoken of as being perfectly dry when it passes from the mill.

It is obvious, therefore, that, since even a good mill leaves 38.37 per cent of the water of the cane in the bagasse, there also remains along with this water a large amount of sugar, and that this amount, if not equal to that estimated above, is yet sufficiently great to demand that only such mills should be used as will secure the greatest percentage of juice.

If, in the above calculation, the amount of sugar lost is in proportion to the per cent of water remaining in the bagasse, it is clear that 46.22 : 28.78 :: 9.477 : 5.901; *i. e.*, while, in the expressed juice there is an amount of sugar equal to 9.48 per cent of the weight of the cane,

there is an amount of sugar equal to 5.90 per cent of the weight of the cane left in the bagasse, equal to 62.27 per cent of the amount actually expressed in the juice, and equal to 38.40 per cent of the total amount present in the cane, which, as will be seen, is equal to 15.38 per cent of the weight of the stripped stalk.

From this it would appear, that the general estimate as to the proportion of sugar actually recovered in a marketable condition is not far from the truth, the several sources of loss being given as follows:

	Per cent.
Left in bagasse	6
Lost in skimming	2.5
Lost in molasses	3
Raw sugar obtained	6.5
Total in cane	18.

Loss of Sugar in Bagasse.

In 1879, the following experiments were made at the Department of Agriculture, at Washington, to determine the loss of sugar in the bagasse:

Two varieties of sorghum and one of maize stalks were selected for the experiment. Carefully selected stripped stalks of each kind were taken, and, in order to obtain an average, each stalk was split lengthwise into halves. The half of each kind was carefully weighed, dried, and analyzed; the other half of each variety was passed through the mill, and the bagasse weighed, dried, and also analyzed. From the results given below it will be seen, that in each case the per cent of water present in the cane was less than the per cent remaining in the bagasse; the average per cent of water in the three varieties of cane analyzed being 80.2 per cent, while the average per cent of water in the three bagasses is 85.5 per cent. This rather surprising result is of course due to the fact that the expressed juice, which averaged 48.24 per cent of the weight of the stripped stalks, contained a larger percentage of solid matter than did the fresh cane.

It will be observed also in these results, that the amount of sugar expressed in the juice was greater in proportion than would be due to the amount of water expressed; for, while not more than half the water was expressed, it appears that an average of four-fifths of the sugar in the cane was expressed with the water. From the published results of numerous other experiments, it would appear that the proportional amount of sugar which is expressed with the ordinary mill pressure is not a constant quantity, but depends upon the amount present, since the following results show a wide variation in this respect; for, while the per cent of water in the Honduras and Sugar Corn was nearly the same, as also the per cent of juice expressed, the total sugar found in the

Honduras was nearly twice the amount found in the Sugar Corn, and, while only 15.2 per cent was lost in the bagasse from the Sugar Corn, there was 23.8 per cent lost in the bagasse from the Honduras. It is of great practical importance that this matter should be more thoroughly investigated.

LOSS OF SUGAR IN THE BAGASSE.

	Honduras.	Honduras.	Early Amber.	Early Amber.	Sugar Corn.	Sugar Corn.
Weight of stripped cane.......pounds..	1,428	1,390	651	905	832	875
Weight of juice ....pounds..	....	666	....	417	....	415
Weight of bagasse.......pounds..	....	724	....	458	....	460
Per cent of juice	....	47 91	....	49.39	....	47.43
Per cent of bagasse.......	....	52.09	....	50.61	....	52.57
Per cent of water in cane.......	80.0	....	75.7	....	84.9	....
Per cent of water in bagasse.......	....	84.0	....	83.7	....	88.7
Per cent of dry matter in cane.......	20.0	....	24 3	....	15.1	....
Per cent of dry matter in bagasse.......	....	16.0	....	16.3	....	11.3
Per cent of sugars in dry bagasse.......	....	21.8	....	19.4	....	10.1
Per cent of sugars in dry cane.......	38.1	....	34.7	....	26.0	....
Per cent of sugars in fresh cane.......	7.63	....	8.44	....	3.93	....
Per cent of sugars in fresh bagasse.......	....	3.48	....	3.16	....	1.14
Per cent of sugars in bagasse to that in cane.......	....	45.7	....	37 4	....	29 0
Per cent of sugars lost in bagasse.......	....	23.8	....	18.9	....	15.2

In 1882, experiments were made with a large variety of sorghums, the results of which were as follows:

Analyses of Bagasses from Sorghum.

The following table gives the analyses of twenty samples of bagasses from nine varieties of sorghum; also, for purpose of comparison, analyses of the juices expressed from the canes are given on page 223.

Excluding the analyses of the suckers and leaves, as not being comparable with the others, the average result of the proximate analyses is as follows:

AVERAGE COMPOSITION OF EIGHTEEN BAGASSES.

	Percent.
Ether extract (fats, chlorophyl, etc.).......	1 43
Alcohol extract (sugars, salts, etc.).......	20 75
Water extract (soluble albumenoids, gum, etc.)	1.48
Insoluble matter (fiber, silica, etc.).......	76.34
	100.00
Albumenoids (N., × 6.25).......	3.17
Crude fiber.......	23 19
Sucrose.......	9.94
Glucose.......	3 84
Ash.......	2 77
Water.......	4 41
Undetermined.......	52 68
	100.00

The average percentage of juice and bagasse obtained, and the composition of the juice, was as follows:

	Per cent.
Juice expressed	57.61
Bagasse	42.39
Water in bagasse	54.24
Dry bagasse	45.76
Sucrose in juice	12.92
Glucose in juice	1.29
Solids not sugar in juice	2.94
Polarization of juice	12.72

Specific gravity of juice, 1.0726.

ANALYSES OF DRIED BAGASSES.

Date.	Variety.	Per cent ether extract.	Per cent alcohol extract.	Per cent water extract.	Per cent insoluble residue.	Per cent nitrogen multiplied by 6.25.
Sept. 14	New variety (H. S. Coll)	1.84	19.46	1.37	77.33	2.813
14	White Liberian (Nesbit)	1.25	18.33	1.84	78.58	3.125
21	New variety (H. S. Coll)	1.20	18.25	1.58	78.97	2.813
21	White Liberian (Nesbit)	1.72	20.97	1.60	75.71	3.125
23	New variety (H. S. Coll)	1.07	20.52	1.46	76.95	2.813
23	White Liberian (Nesbit)	1.17	19.50	1.21	78.12	3.000
Oct. 3	Suckers from rows 2, 3, 4, 5	2.20	11.78	1.08	84.94	5.625
3	Leaves from rows 2, 3, 4, 5	5.26	12.70	1.17	80.87	13.125
10	Neeazana	1.75	23.17	1.34	73.74	3.000
11	Link's Hybrid	1.55	23.27	1.55	73.63	3.500
12	White Liberian (Nesbit)	1.28	17.83	1.79	79.10	3.000
13	White Liberian (Leaming)	1.57	17.68	.90	79.85	3.125
18	White Liberian (Leaming)	1.19	22.22	1.71	74.88	4.000
18	Early Amber	1.55	21.26	1.39	75.80	2.125
18	Link's Hybrid	1.43	19.18	1.58	77.81	3.125
30	West India	1.52	22.92	1.37	74.19	3.313
31	Red Sorgho	1.22	19.51	1.17	78.10	3.125
Nov. 1	West India	1.85	22.95	2.02	73.18	3.500
2	West India	1.49	22.17	1.38	74.96	4.000
Dec. 8	New variety (R. Haswell)	1.11	24.34	1.32	73.23	3.500
	Average	1.43	20.75	1.48	76.35	3.167

Date.	Variety.	Per cent crude fiber.	Per cent glucose.	Per cent sucrose.	Per cent ash in alcohol extract.	Per cent total ash.	Per cent moisture.
Sept. 14	New variety (H. S. Coll)	27.475	3.25	9.75	.84	2.70	4.25
14	White Liberian (Nesbit)	21.875	4.25	7.10	.93	2.60	3.75
21	New variety (H. S. Coll)	21.600	3.25	8.80	.88	2.45	4.00
21	White Liberian (Nesbit)	21.050	3.75	7.40	1.03	2.95	4.65
23	New variety (H. S. Coll)	20.775	2.75	10.45	.87	3.05	5.20
23	White Liberian (Nesbit)	21.475	3.75	7.60	1.00	2.80	4.55
Oct. 3	Suckers from rows 2, 3, 4, 5	25.525	2.00	.95	1.58	4.10	3.95
3	Leaves from rows 2, 3, 4, 5	20.250	1.25	.50	1.82	5.90	3.95
10	Neeazana	21.100	5.50	10.00	.74	3.00	4.40
11	Link's Hybrid	23.725	6.75	7.10	1.20	3.00	5.90
12	White Liberian (Nesbit)	19.975	..	10.00	.89	2.50	5.15
13	White Liberian (Leaming)	25.550	3.50		.94	2.85	3.80
18	White Liberian (Leaming)	22.025	2.75	13.50	1.04	2.70	5.65
18	Early Amber	22.625	2.50	12.75	.97	2.20	5.00
18	Link's Hybrid	23.975	3.00	9.50	.89	2.95	4.30
30	West India	24.400	4.50	8.00	.87	2.75	4.65
31	Red Sorgho	25.750	3.25	10.50	1.16	2.60	4.20
Nov. 1	West India	23.150	4.25	11.75	1.02	2.95	3.10
2	West India	23.975	4.75	10.25	.77	2.55	4.45
Dec. 8	New variety (R. Haswell)	26.950	3.50	14.50	1.23	3.20	3.35
	Average	23.192	3.84	9.94	.96	2.77	4.41

LOSS OF SUGAR IN THE BAGASSE.

The most important point established by these analyses, is the very considerable loss of sugar, owing to the impossibility of a mill to express all the juice. We often hear of bagasse as coming from the mill "perfectly dry;" but it will be seen that although the juice obtained from these canes was much greater in amount (57.61 per cent) than is usually obtained in practice, still the average amount of water remaining in the bagasse was 56.26 per cent, and if to this we add the alcohol and water extracts of the bagasse, which would naturally constitute the juice, we should have remaining in the bagasse $(20.75+1.48)\times .4576=10.17+56.26=66.43$ per cent of juice still remaining in the bagasse; that is, 64.41 per cent of the weight of the bagasse as it came from the mill.

Surprising as this may appear to those who have not considered it, there can be no doubt but that the above is even short of the truth.

The average amount of juice obtained was 57.61 per cent, and the total sugars in the juices averaged 14.21 per cent, or 8.19 per cent of the weight of stripped cane. The average of the dry bagasses gave 13.78 per cent of total sugars, or 6.31 per cent of total sugars in the fresh bagasses; it follows, therefore, that the bagasses, as they came from the mill, contained 77.05 per cent as much sugar as was expressed by the mill from the fresh canes.

Since there was 6.31 per cent of total sugars in the fresh bagasses, it follows that the amount of sugars in the bagasse equaled 2.67 per cent of the weight of the stripped cane; also as the total sugars in the expressed juice was 14.21 per cent, it follows that the amount of sugars in the juices equaled 8.19 per cent of the weight of the stripped cane, and, therefore, the total sugars in the stripped cane was equal to 10.86 per cent of the weight of the cane; and there was lost in the bagasse 24.62 per cent of the total sugar present in the cane.

That this estimate falls short of the truth is obvious, when we consider that the juices were analyzed the day they were expressed, while the bagasses in drying had lost much of their sugar through fermentation, as was seen to be true in the analyses of fresh juices as compared with the analyses of the same juices when dried.

Since the water contained in the plant is far more than sufficient to hold in solution all the sugars present, there appears no good reason to doubt that the juice left in the bagasse is identical in its composition with that expressed; but if we examine the average results of the analyses of juices and bagasses in the table, we find that the per cent of sucrose in the total sugars of the juices was 90.92, while in the bagasses it was 72.13; while, if we examine certain of the analyses, we find a discrepancy still greater. For example, analysis, (page 223) of the juice of Link's Hybrid, gives us in the juice 95.39 per cent of sucrose and 4.61 per cent of glucose in the total sugars; while the analysis of the bagasse from this cane shows the two sugars to be in this ratio: Glucose, 48.74 per cent; sucrose, 51.26 per cent.

Such a result is, beyond question, due to the fact that, during the process of drying the bagasses, there had been an inversion of much of the sucrose, and in all probability a loss of glucose by fermentation.

Prof. Geo. H. Cook, director of the New Jersey Agricultural Experiment Station, at New Brunswick, in the report on his work, alludes to the waste in the

use of the ordinary mills for extracting the juice, and estimates the loss as being equal to 40 per cent of the sugar present in the cane.

When we consider the magnitude of this industry, this estimated loss assumes immense proportions.

Fully $300,000,000 worth of sugar is now annually produced from cane by practically the same methods used in the production of sorghum sugar. According to the estimate of Prof. Cook, then, it appears that there is annually lost in the bagasse two-thirds as much, or $200,000,000 worth of sugar. It would appear most desirable, that some method be devised by which this enormous waste may be prevented.

The following analyses of bagasse from sugar-cane show results comparable with the above:

	A.	*B.*	*C.*
Per cent of juice expressed	60.0	70.0	80.0
Per cent of water in bagasse	23.0	15.2	7.2
Per cent of sugar in bagasse	6.0	3.8	1.8
Per cent of fiber, etc., in bagasse	11.0	11.0	11.0
	100.0	100.0	100.0

The percentage composition of the bagasses is as follows:

	A.	*B.*	*C.*
Water	57.5	50.7	36.0
Sugar, etc	15.0	12.7	9.0
Fiber, etc	27.5	36.7	55.0
	100.0	100.1	100.0

It will be seen that, when 60 per cent of the weight of the cane was expressed as juice, there yet remained in the bagasse 15 per cent of its weight as sugar, and an amount of water quite equal to that in the unpressed cane. It appears also that even in the cane where the percentage of juice was 80, the fresh bagasse contained 9 per cent of its weight of sugar.

The importance, then, of a mill which shall express the greatest amount of juice is obvious, provided the juice obtained by the increased pressure is of equal purity with that obtained by less.

Upon this point there exists a diversity of opinion, but the matter does not appear to have been made the subject of such experimental investigation as its importance demands. It seems rather, in many cases, to serve as a convenient excuse for what would otherwise appear as a wasteful method of manufacture; as also for the makers of mills, who have found it practically impossible to surpass a certain limit in the amount of juice expressed.

In several experiments with a second-hand mill, as compared with a new one, the following results were obtained:

Mill.	Per cent of juice unstripped stalks.	Specific gravity of juice.	Per cent of syrup in juice.
Old mill	48.96	1058	15 18
New mill	57.16	1087	20.29

By comparing the percentage of juice obtained and the specific gravity of the juice in the first and last experiments, it will be seen that the former results are to the latter as 100 to 175; while, if we compare the percentage of juice obtained and the percentage of syrup in the juice, the former experiments in their results are to the latter as 100 is to 156. This apparent discrepancy is due to the fact that, when the latter experiments were made, it was possible to carry the concentration of the syrup to a greater density than in the former cases, and hence a given amount of syrup in this latter case represents a far higher content of sugar than in the former; but these results clearly indicate that, with a good mill, results from 50 to 75 per cent greater than those obtained in the first experiments could be confidently relied upon.

As has been said above, this matter is too important to rest upon other than repeated and well established experimental results.

The Speed of the Rolls.

This is a matter of extreme importance. We have already seen that the maximum pressure exerted by any mill is instantaneous, but the length of time during which the pressure upon the cane is approximately at its maximum, will depend upon the diameter of the rolls and their velocity of revolution. Careful experiments have shown that, without any change in the relative position of the rolls, a greatly increased amount of juice may be secured by diminishing their speed. It is generally true that the speed of the mill is too great.

Repeated experiments have all tended to prove that, while only 46 per cent of the juice is extracted by a speed of 8 revolutions per minute, as much as 70 per cent is obtained by the same mill when the speed is reduced to $2\frac{1}{2}$ revolutions per minute.

Comparative trials were made with a mill, the rollers of which were 22 inches in diameter and 48 inches long, the average speed being 24

feet per minute, and another with rolls 36 inches in diameter, and 66 inches long, the average speed being 9 feet per minute.

The first gave 59.9 pounds of juice from each 100 pounds of cane, and the latter 77.61 pounds of juice to 100 pounds of cane. The first gave 9.36 pounds of sugar from each 100 pounds of cane, the latter 14.87. One gallon of juice from the first gave .572 pounds of molasses, and 1.672 pounds of sugar, and 1 gallon of juice from the other gave .66 pounds of molasses, and 2.07 pounds of sugar.

According to this calculation, there was lost in the bagasse of each 100 pounds of cane ground 7.53 pounds of sugar in the first case and 2.47 pounds in the latter, equivalent to an increase on the crop of 46.6 per cent by the slow mill. The above experiments were made with sugar-cane, but will illustrate the principle. Very many experiments are reported from Louisiana bearing upon this question, but generally a difference in the cane used in the two cases vitiates the result.

VARIOUS METHODS FOR THE EXTRACTION OF JUICE.

Although the three-roll mill of capacity suited to the requirements is the ordinary method employed in the extraction of the juices from sugar-cane and sorghum, it is, of course, to be expected that many other methods have been devised to accomplish this result without the enormous and inevitable loss which the system of simple crushing of the cane involves.

It is proposed briefly to refer to those several methods which have been devised, more for the purpose of stimulating experiments and invention than for the full elucidation of the different processes.

The several methods devised for the extraction of sugar may be classed as follows: 1. Multiple rolls; 2. Disintegration of the cane; 3. Maceration; 4. Diffusion.

1. *Multiple Rolls—Auxiliary Mills—Double Crushing.*

One of the largest mills in the world is that belonging to the Khedive at Aba-el-Wakf, in Upper Egypt. This is a three-roll mill, each roll being 48 inches in diameter and 5 feet 6 inches long. The length of time during which the cane remains under pressure (the surface velocity of the rolls being the same) is proportioned to the diameter of the rolls, and although running with a velocity of 36 feet per minute, this immense mill is said to express as high a percentage of juice as the ordinary three-roll mills do at half the velocity. This large percentage of juice obtained with large rolls is due not alone to increased and prolonged pressure, but to the fact that the juice escapes from contact with the bagasse, and thus less of it is absorbed. There is an

impression widely prevailing, although not sustained by the tests of repeated experiments, as its importance demands, that the juice expressed by heavy and slowly-revolving rolls has its increased quantity fully offset by its diminished quality.

It is urged, therefore, that, in the place of increased pressure and heavier mills, the pressure should rather be diminished, but continually repeated; and this view has led to the experimental adoption of more rolls—as four arranged in two pairs—the bagasse from the first two being received and again pressed by the second pair. This is, in effect, only a modification of the three-roll mill, so far as repeated pressure is concerned; but, by separating the two pairs of rolls, opportunity is offered to sprinkle the bagasse, or steam it, before it passes the second rolls. This is called maceration, and will be considered by itself, below. Mills with five, six, and even nine rolls, have been employed; but generally the result of such experiments has been the final return to the three-roll mill.

The objections to the use of the greater number of rolls being the cost of mill, the increased power required, and the grinding up of the bagasse by the repeated pressure.

2. *Disintegration of the Cane.*

Several methods have been devised, depending for their efficiency upon the grinding up of the cane in a pulp, and the extraction of the juice by hydraulic presses. One machine, in its construction resembling the common mill for mincing meat, consists of a series of knives on a central shaft, revolving in a cylinder, upon the inner surface of which another series of knives are arranged, which meet those upon the central shaft in the manner of shear blades. By the spiral arrangement of these sets of knives, the cane, which is fed in at one end, is cut up, carried along, and discharged as pulp at the other end of the machine. A machine of the above construction, at Guadeloupe, having a capacity of five tons of cane per hour, gave, in five experiments, the following per cent of juice, the pulp being subjected to pressure by means of a hydraulic press: 70.0, 72.7, 75.6, 76.2, 76,8, or an average of 74.26 per cent.

Another machine consists of a series of circular saws upon a common shaft, the bundles of cane being by them converted into sawdust, which is subjected to pressure, as in the former case.

3. *Maceration.*

This process, which, by one method or another, has been the subject of repeated experiment, consists in moistening the bagasse as it comes

from the ordinary three-roll mill, by either hot or cold water or steam, and then subjecting it to pressure again. For this purpose, the bagasse is received upon a continuous carrier of wood or cloth, and, while slowly passing to the second set of rolls, is exposed to a spray of water or steam. The diluted juice obtained in this second pressure is generally used as sprinkling water, to moisten fresh portions of bagasse, until it attains, by repeated use, density sufficient for the sugar to be extracted from it economically.

In this process there is a very considerable saving of sugar, which amounted, with sugar-cane, according to the data given in "Sugar Growing and Refining" (page 159), to 15.7 cents upon each 100 pounds of cane used, or, estimating 10 tons of canes to every hogshead of sugar produced, to a saving of $35.16 on each hogshead.

But from this must be deducted the increased cost of the "plant," of labor, and of manufacture, owing to the greater amount of water necessary to be evaporated, so that the conclusion given is as follows: "It would appear, from numerous statements, that the total extra cost of procuring the extra yield of sugar is about 50 per cent of the value of the extra sugar."

4. *Diffusion.*

All the processes thus far mentioned for the extraction of the juice from sugar-cane and sorghum, depend, for their success, upon the rupture of the cells of the plant, and the pressing out of the juice; and, in the process of maceration, the principle is mainly the washing off of the juice remaining in the bagasse. In the process of which we are now to speak, the extraction of the sugar depends upon an entirely different principle, known in science as Diffusion, Dialysis and, Osmosis; and to fully understand the matter, it is necessary to again refer to the physiological structure of the stalk of cane or sorghum.

We have seen, p. 259, that the stalk is made up of an outer rind or shell, firm and woody in its structure, containing within a soft, juicy pith, and that this pith consists of numberless cells, composed of cellulose similar to the woody fiber of other plants, the juice being contained in these cells, as is the juice of an orange in the larger cells which make up the pulpy portion of that fruit.

Now, it has been found that, if slices of cane, or of sorghum, or of the sugar beet, are immersed in water, in a short time the water will have become perceptibly sweet, and this sweetness will increase up to a certain degree, after which it will remain the same. If now we replace this sweet water with a fresh portion of pure water, we may extract an additional amount of sugar, and by repeating this operation a few times, it will be found that the sugar has been entirely removed

from the slices of stalks or beets. This result is due to the principle of diffusion, dialysis, or osmose, as it is termed. It has been found that certain substances, when in solution, will thus pass through animal or vegetable membranes, as bladder, animal or vegetable parchment, when such solution is separated from water by the intervention of either of these materials. The cells of plants are composed of matter, which also permits the passage of such materials under similar conditions. The process will continue, until the amount of the material in solution outside is equal to that inside the containing vessel.

But, while certain substances will thus readily diffuse, another class of substances will not. To the former the name *crystalloids* has been given, because it is found that those substances which crystallize, as sugar, salt, and similar bodies, are diffusible; to the latter class the name *colloids* has been given (a word meaning glue-like), because those substances which, like glue, do not crystallize, are also found not to be diffusible.

It is now interesting and important to observe that, in the cells of the cane, sorghum, or beet, there are found in the juice substances belonging to both these classes, and also that, while the desirable substance sugar is quite diffusible, those substances which are most troublesome to the manufacturer of sugar, as the nitrogenous matter, the gum, and the starch, are not diffusible. These substances existing together in the juice are expressed by the common mill, and, in addition, there is always a considerable amount of mechanical impurity, as dirt, fragments of cane, and so forth, all of which add to the difficulty of securing the sugar in a commercial condition.

Besides the sugar, there are several other constituents of the juice which are also diffusible, as the many salts. Owing to the large quantity of these relatively in the beet, the advantage of this system for beets does not appear to be so decided as it seems that it might prove if applied to sorghum and cane. But, while this system is in almost universal use in the production of beet sugar, it appears as yet scarcely to have made other than an experimental advance in the working of cane or sorghum.

It is possible, by this system, to remove practically all the sugar from the stalks or beets; and we have seen that, by the roller mill, it is estimated that fully one-third the juice is left in the bagasse; and many experiments show that the juice remaining in the bagasse is equally rich in sugar with that expressed.

A review of the attempts to apply this system to sugar-cane will, therefore, be of interest. The methods are practically the same, and consist in cutting the cane in slices from one-sixteenth to one-eighth of

an inch in thickness. These slices are packed in appropriate receptacles, which are arranged in a train in such a manner that, after filling the first with water, it may, after a certain time, be discharged into the second, the third, fourth, and so on, until the water has become as rich in sugar, approximately, as the juice of the stalks or beets. So soon as the water is discharged from the first receptacle to the second, fresh water is again added to the contents, and this is in succession delivered into the second, third, fourth, etc. By this means, the sliced cane or beet is successively treated with fresh portions of water, until at last the sugar has been entirely removed. The diffusion water being necessarily used upon portions increasing in their content of sugar, until the water contains sufficient to be profitably treated for sugar.

In order to render insoluble certain constituents of the juice, it has been the practice to first steam the fresh slices, or treat them with hot water; and, to remove from the diffused liquor other impurities, it has been advised to sprinkle lime over the slices in filling the receptacles. It would appear desirable to use for this purpose a mixture of lime and sulphite of lime, in order to avoid any tendency to fermentation.

The following results are recorded in "Sugar Growing and Refining," p. 190—the juice from the canes giving 7¾° B. The water had, in succession, been passed through the series, until seven vessels, each containing 120 cubic feet, and holding 4,200 pounds of cane chips, and 3,250 pounds of water, were filled with the diffusion liquor:

No. of vessels.	Temperature of juice.	Specific gravity.	Per cent sucrose.	Density, Beaumé.
1	21°C.= 70°F.	1.00030	0 08	0.048
2	29°C.= 85°F.	1.00310	0.80	0.44
3	32°C.= 90°F.	1.00554	1.40	0.80
4	49°C.= 120°F.	1.01134	2.90	1.6
5	93°C.= 200°F.	1·01618	4.12	2.3
6	87°C.= 189°F.	1.02537	6.45	3.6
7	91°C.= 196°F.	1.04599	11.40	6.3

It will be observed, that, if the diffusion liquor in vessel 7 be regarded at the maximum of saturation with such cane chips as were used in this experiment, that the following represents the per cent of the total sugar removed from the successive vessels:

No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.
Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
99.74	93 0	87.3	74.6	63.5	42.9	0.0

The complete extraction of the sugar by this process, appears, then, to be easy of accomplishment.

An analysis of the mill juice and diffusion liquor of the cane, shows their relative composition:

ANALYSES MILL AND DIFFUSION JUICES.

Mill juice.	Diffusion juice.	
1.05746	1 04620	Specific gravity.
11.80 per cent	9 65 per cent	Sucrose.
1.68 per cent	1 38 per cent	Glucose.
.62 per cent	.42 per cent	Other solids.
14.10 per cent	11 45 per cent	Total.

The difference in strength of the two juices is due to the fact, that the diffusion juice was diluted by about 20 per cent additional water used in the operation. The evaporation of this excess of water must be taken into account in the estimate of cost of production of sugar by this process. In the above experiments, each vessel contained 4,200 pounds of sliced cane; and from each 4,290 pounds of diffusion juice was drawn off; 113 gallons of this diffusion juice being equivalent to 100 gallons of mill juice. The 4,290 pounds was equal, therefore, to 3,796 pounds of mill juice, or 88.5 per cent of the weight of the cane.

In the Aska District, Madras, India, the following results were obtained in the diffusion process:

The average composition of the juice of the canes, obtained by diffusion, was as follows:

Sucrose	81.70 per cent.
Glucose	12 72 per cent.
Ash	1 77 per cent.
Other solids	3.81 per cent.
	100.

The per cent of total solids in the juice averaged 16.53.

The composition of the "masse cuite" (the mixture of sugar and molasses obtained by evaporation) was as follows:

Water	5.110 per cent.	
Sugar	76 000 per cent	80.09 per cent.
Glucose	12 740 per cent	13 43 per cent.
Ash	1 507 per cent	1.59 per cent.
Other solids	4 643 per cent	4.89 per cent.
	100.	100.

It will be seen how close in composition the masse cuite is to that of the diffusion juice, showing that the amount of inversion of sugar, during the process, was very little—certainly no greater than that incurred in the ordinary processes. But results of an experiment with the same diffusion process, in the West Indies, were apparently not so satisfactory, it being claimed that the syrup from diffusion juices would not crystallize so readily as ordinary syrup, and that much of the sugar was therefore lost in the molasses. The following analysis of the molasses obtained would apparently justify such conclusion:

Water	20.08	per cent.
Sucrose	63.82	per cent.
Glucose	12.38	per cent.
Other solids	3.72	per cent.
	100.	

In the experiment in which the above given molasses was obtained, the following results were secured in sugar and molasses:

Sugar	5.234	per cent of weight of cane.
Molasses	5.193	per cent of weight of cane.

But it was held, that a much larger amount of sugar could have been obtained from the molasses by subsequent treatment, as seems very probable in consideration of its composition, as given above.

In conclusion, it would appear that, although the results are not yet such as could be desired, there is reasonable expectation that this process may be, by a little care, brought to perfection, and wholly supplant the present wasteful method of manufacture.

At present, the following points appear established: 1. The possibility to completely remove the sugar from the cane by this process. 2. The separation, at the outset, of all of those mechanical impurities, and many of those chemical constituents of the juice which invariably are present when it is expressed by the common mill, and which are obstacles to the production of sugar.

This matter will again be discussed under the chapter upon Waste Products, and the experiments made in recovering sugar from the bagasse.

CHAPTER IX.

(*a.*) Defecation, principles of.
(*b.*) Defecation with lime.
(*c.*) Other agents in defecation.
(*d.*) Sulphurous acid and sulphites in defecation.
(*e.*) Experiments in defecation.

DEFECATION, PRINCIPLES OF.

The juice extracted from the sorghum, or cane, by either of the processes already described, is found to consist of a solution of not only sugar, but of other soluble constituents of the cane which may be present. Besides, the juice secured by the roller mill contains a considerable portion of mechanical impurities, *i. e.*, those which are suspended in the juice as solid particles, and are visible to the eye, often being in a state of subdivision so small that the effect of these impurities may be only to render the juice turbid instead of clear, as it should be when free from them.

The juice obtained by the process of diffusion, is quite free from such impurities, and is generally clear, containing only those substances which are in solution with the sugar.

The composition of the juice of sorghum, as obtained by the roller mill, is given upon page 252.

The production of sugar from the juice is accomplished by the removal of the water and those constituents of the juice, wholly or in part, which are present with the sugar. The more perfectly this is done, the larger the amount of sugar which may be obtained from any juice.

Defecation, as the word implies, is the removal of impurities; and from what has already been said, it is obviously the most important operation in the manufacture of sugar. All the other operations are mechanical merely.

Defecation is both a mechanical and chemical problem, since the impurities are both mechanical and chemical, and even the removal of the latter is only possible, for the most part, after, by some means, they have been converted into mechanical impurities.

As the character and composition varies so greatly, as to the impurities of the juice, it naturally follows that the methods which have been suggested, and which have been adopted in practice, have differed as widely. That there yet remains great room for improvement, none will more readily admit than those fully conversant with the advantages and defects of the present methods. In the hope that the inventive faculties of those who are engaged in this new sorghum sugar industry may be stimulated and directed, it will be the aim of this chapter, not only to describe the methods of defecation in use or suggested, but also, so far as is possible, to consider the principles involved in the several methods.

Mechanical Impurities of Juice—Nature of, and Methods of Removal.

The mechanical impurities of the juice of sorghum are fragments of the cane, dirt, wax, and starch.

We have already seen how readily fermentation is excited in a sample of juice by the presence of the bagasse with the formation of what appears to be the so-called gum, which has proved so troublesome in the extraction of sugar from syrups. The most careful experiments with freshly expressed juices, have invariably failed to reveal even a trace of this gum; so that its subsequent presence in the products proves conclusively that it must be the result of the method of manufacture. Owing to the trouble it produces in purging the sugar, and the loss of sugar it causes, the source whence it is derived, and the method by which it is produced, should be carefully investigated, so that the source may be removed, or the method of its production avoided or modified.

Nearly every sample of sorghum juice will reveal the presence of starch grains, which will give their characteristic color with iodine solution; and we have already referred to the presence of the starch in the slices of cane when examined under the microscope. In the crushing of the cane these grains are mechanically carried along with the juice.

The presence of this starch, although the actual amount is small, is beyond question highly detrimental to the juice, and does not appear to have received the attention it demands. Its removal must be accomplished at the outset, if at all, since the heat employed in the ordinary methods of defecation would speedily convert it into a form rendering its removal, by mechanical means at least, quite impossible. The size of these starch grains is such as to preclude their separation by ordinary filtration, such as would readily suffice for the removal of the principal mechanical impurities.

Preliminary Filtering.

This may be accomplished in many ways. Many are accustomed to allow the juice, as it flows from the mill, to fall into a large bucket, from the bottom of which a pipe conveys the juice to the storage tank. (See Plate, small mill.) This bucket is nearly filled with clean hay or straw pressed closely down, by which all fragments of cane and the coarser impurities are removed from the juice. In larger mills the juice from the mill flows through a wire gauze, with meshes from 50 to 70 to the linear inch, and this guaze filter is arranged as a continuous belt, which, by its slow revolution, presents a fresh surface to the stream of juice. The accumulating impurities are removed during its revolution by scrubbing brushes and a tank of water through which the belt is made to pass.

Another cheap and very efficient filter is made by having a box about 30 inches deep, 30 to 40 inches square at the top, and tapering to 20 to 30 inches at the bottom. About four inches from the bottom a false bottom is placed perforated with holes, and upon this coarse gravel, covered by layers of increasing fineness in succession to the top, which is clean, fine sand. The juice is admitted into the open space below, under a slight pressure, and, filtering upward through the gravel and sand, escapes by a pipe above. Properly constructed, this filter will deliver the juice quite free from mechanical impurities. In case the filter becomes stopped up, the fluid contents may be removed by a stop-cock, which is inserted into the open space at the bottom, when a pail or so of water will wash out the accumulated impurities. This filter should be thoroughly washed with water when not in use, and a little lime should be added to the last washings in order to avoid fermentation.

A convenient and effective filter may be prepared by taking an ordinary grain bag, holding 2 bushels, and splitting it lengthwise, then stitching each half into a bag equal in length to the original but of half the width. Into each of these an entire bag may be inserted, and the upper edges of the two bags sewed together. The inclosed bag will thus be compressed into a series of folds, and in this way present an increased surface to the juice to be filtered. It will be found an advantage to pack the inner bag as full as possible with fine, clean hay, which will greatly assist the filtering by keeping the surface of the bag from being stopped up by the impurities filtered out.

For convenience, four such filters may be fastened to a frame, and placed in a common barrel, with a stop-cock at the bottom for drawing off the filtered juice. These, and all other filters, should be fre-

quently cleansed, and the straw, hay, sand, and gravel, should be either replaced by fresh material, or thoroughly washed with water, to which a little lime has been added.

Where large quantities of juice are to to be filtered, a large number of bag filters are so arranged as to be fed from a common tank, and filtering into a common receptacle.

Bags of suitable texture are woven seamless for such purpose. Filter presses of many different constructions have been devised, the general principle being to present large surfaces of the filter to the juice. For a full description of these, reference is made to the more elaborate works which treat of the manufacture and refining of sugar. Besides the several varieties of filters already described, all of which depend upon the removal of impurities through their mechanical entanglements in the material of the filter, there is in very extensive use, for the removal of other impurities, filters of charcoal and bone-black, *i. e.*, an animal charcoal prepared by burning bones in ovens or retorts, with the exclusion of the air, in a manner similar to the production of ordinary wood charcoal.

It is found by filtering juice or semi-syrup through a layer of bone-black of sufficient depth, that not only are the mechanical impurities removed, as would be expected, but all the coloring matter also, so that the juice or syrup becomes not only clear, but colorless as pure water. It is also found that the bone-black retains other of the impurities of the juice or syrup, as the albumenoid or nitrogenous substances, gum, etc., but it is found that the bone-black soon becomes so charged with these impurities, that it ceases to have any effect, and must then be washed, dried, and reburned before it is again fit for use.

In the process of refining the raw sugar, filters varying in length from 10 to 50 feet are used, and it is found that generally about one ton of fresh bone-black is needed for each ton of sugar refined; but, since it may be used over and over again, only needing this revivification, as it is termed, with the addition of so much as may be lost in the operation of washing, drying, and burning, the expense attending it is largely the original cost of the plant and material, as also the additional labor involved in its use.

The use of bone-black is only practicable with large central factories working up very large quantities of cane, or refineries receiving the product of many smaller manufacturers. It is not within the limits of the farmer or sugar planter; and, although as invaluable to the refiner as it is indispensable, its economical use involves the investment of a large capital.

Settling Tanks.

Besides the use of filters, for the removal of mechanical impurities, the employment of settling tanks for the fresh juice, has been practiced by some with excellent results.

The only danger in this practice is, that fermentation is likely to take place by letting the juice stand; but this has been obviated by treating the juice with sulphurous acid between the mill and the settling tank. In this way it has been found practicable to keep the juice of sugar-cane from 6 to 10 hours, and, upon standing, a large amount of slimy sediment was separated from the juice. It is well to have the juice drawn off from an inch or two above the bottom of the tank; the sediments being reserved for vinegar, or passed through the filter before it is added to the remainder of the juice.

Effect of Heat on Juice.

The juice, even after the most careful filtration, still retains many impurities, which may by other means be removed. We have seen that, in its natural state, it has an acid reaction due to the presence of acid salts of organic acids, of the nature of which we as yet know little.

There are also present certain nitrogenous matters, besides the inorganic constituents or ash of the juice. The effect of heat alone, is to cause the coagulation of at least most of the nitrogenous matters, and the formation of an abundant scum; and very many, seeing such quantities of impurities removed by heat alone, are accustomed to rely upon it solely in defecation. This is a serious error, although it must be admitted that excellent syrup, in appearance at least, has been made without the use of any thing but the skimmer to remove those impurities which arose as the juice was being evaporated. Heat also, by destroying the germs, prevents or retards fermentation. Heat is a valuable, but not a complete agent in the defecation of the juice.

Effect of Lime on Juice.

The agent which is almost universally employed in the defecation of saccharine juices is lime, and, owing to its cheapness, general accessibility, and the excellent results which attend its intelligent use, a description of its chemical properties, preparation, and use in defecation, is important.

Lime belongs to the class of bodies known to the chemist as alkaline earths, because, in its chemical nature, it appears to stand midway between the alkalies and the earths. Athough far less soluble in water than are the alkalies, it is yet sufficiently soluble to form a solution pretty strongly alkaline in character, a clear colorless liquid, known as

lime-water, which contains, at ordinary temperatures, about one part of lime by weight to 730 parts of water. Its solution gives the ordinary reactions for alkalies, viz.: it will turn reddened litmus paper blue, and imparts a brownish red color to yellow turmeric paper. These test papers are invaluable to the sugar manufacturer, and they may be had of any druggist at a few cents cost for enough to last during the season. They are prepared by extracting with water the coloring matter of the commercial litmus, which consists of little clay pellets saturated with the coloring matter of this lichen, and then wetting strips of white unsized paper with the solution and drying them. The turmeric is prepared from the powdered curcuma root of the shops, which, extracted with alcohol, will give a yellow color to strips of paper immersed in it, and then dried. These papers are best kept in a stoppered bottle, and in the dark.

Lime is generally used in defecating saccharine juices in the form of the milk or cream of lime, both being practically the same, except that the latter is the stronger.

Cream or milk of lime is prepared by carefully selecting the best specimens of well burned lime, and then slaking them with water, precisely as though the preparation of a white wash for the walls was the object. After slaking, it would be well to pour the whole through a sieve, in order to remove any lumps which had not perfectly slaked. Water is added in quantity sufficient to make, when thoroughly stirred up, a thin cream or thick milk in appearance and consistence; hence the name.

It may be kept for almost any length of time, as only a small portion of it will suffer change from the carbonic acid of the air, by which such portion is converted into the carbonate of lime. It is well to make, in advance of the season's work, a quantity sufficient to last through the season, in order that a supply may be always at hand.

The effect of the addition of lime to the juice of sorghum or cane, is to neutralize the acidity which these juices have in their normal state. This change may be known by the effect produced upon the test papers, the normal juice being without effect upon the yellow turmeric paper, but turning the blue litmus paper red. (In thus testing a sample of juice, a slip of the paper two inches long and one-fourth inch wide will suffice, and this should be moved about in the juice, in order to bring it in contact with different portions, and allow a few seconds for the reaction to manifest itself.)

After adding the milk or cream of lime in quantity a little more than sufficient to neutralize the acidity of the juice, it will be found that the action upon the test papers is to turn the yellow turmeric to a

brownish-red, and the blue litmus to a purple or red, according as the lime present is in less or greater excess.

The visible effect produced by adding the lime will be the formation of a precipitate throughout the liquid, which was before comparatively clear. This cloudy precipitate will be seen to gather itself in flocks, and these will either slowly settle to the bottom or rise to the top of the mass of juice, leaving at last the intermediate portion quite clear. It will also be observed, that the green color of the juice will change to a yellow (brownish-yellow), leaving the juice, after the separation of the precipitate, of a light sherry-wine color.

The chemical effect of lime upon these saccharine juices is to decompose the several salts of organic acids present, uniting with the acids to form insoluble lime salts, which are precipitated. It is said also to render certain compounds, which were soluble in the acid solution, insoluble, and thus effect their removal. It also, especially in connection with the heat, effects the destruction of the germs of fermentation, and thus keeps the juice sweet. It is, on this account, advisable that the mill, and those vessels in which the juice is stored, should be, when not in use, rinsed out with water, to which enough lime has been added to render it a little milky.

DEFECATION WITH LIME.

After the preliminary filtering or settling of the juice, it is taken into the defecator, and there receives the treatment with lime. The defecator may be either round or square; may be heated by steam coils or by direct heat; although steam is much to be preferred. It is desirable that it should be deep, so that the sediment and scum formed by defecation may, together, occupy but a small section of the depth, thus permitting a large proportion of the clear defecated juice to be drawn off directly, without the necessity of being passed through the filters. A defecator 4 feet wide, 5 feet long, and 3½ feet deep, is a convenient size, and would hold 500 gallons of juice. It should not be filled more than about five-sixths of its capacity, in order to permit the juice to be actively stirred about while adding the lime, and to avoid the danger of overflowing when it is brought to the boiling point. So soon as the steam pipes are well covered with juice, or a sufficient amount has run into the defecator to more than absorb all the heat of the steam or fire, the heat may be applied; and when enough juice has been brought into the defecator, the tempering with lime may begin. For this purpose, a bucket of the cream of lime, with a dipper for ladling it out, an assistant, with a strong paddle, for stirring

up the juice, and several slips of fresh litmus paper, previously reddened by dipping them in fresh juice, should be right at hand.

The lime should be added gradually, with constant stirring, in order that it may be thoroughly distributed through the mass of liquid, and repeated tests are to be made with the litmus paper, until the reddened litmus is turned purple, but not blue; since that would show that too much lime had been added. The turmeric paper would show a faint brownish-red, instead of the yellow, which is its color, in juice which had received the right amount of lime. As the amount of lime which is approximately correct will soon become known, the additions at first may be more rapid than at the close; but, as the point of neutralization is being approached, the greatest care should be exercised to avoid an excess. Should too much lime be accidentally added, a little more fresh juice may be brought into the defecator, although, with care, this will very rarely be necessary.

Owing to the impossibility of having the samples of cream of lime of the same strength, as also the difference in the acidity of juice, it is impossible to lay down any exact rule as to quantity to be added; and the good defecator will always proceed with caution, until experience has taught him how to advance more rapidly. But, with an ordinary defecation of from 300 to 500 gallons of juice, there is always ample time to complete the addition of the lime before the boiling point is reached. So soon as the proper amount of lime has been added, the juice should be left at rest, and the heat increased to bring the whole to the boiling point.

The following phenomena will appear in a good defecation: As the temperature increases, a dark green scum will rise upon the surface, and, if a portion of it is pushed aside, a heavy, flocculent precipitate will be seen distributed through the clear and almost colorless juice. The scum will increase in quantity, and gradually grow darker in color, and more compact, resembling a thick "blanket," as it has been termed. Shortly after, seams will form in the scum "cracking," and here and there the juice (now about reaching the boiling point) will bubble up through points in these cracks, showing a perfectly white foam. So soon as the boiling point is reached, and before the scum has been broken up by boiling, the steam is wholly turned off, or the fire is withdrawn. And here is one of the great advantages of steam, that the heat may be almost instantaneously withdrawn. If direct heat is used, care should be exercised that the fire be nearly through by this time, and the heat, at the last, urged by a few sticks of light wood, which may be easily quenched. The object of preventing the boiling of the

juice, is to avoid the mixing up of the scum in the juice, as it is now in a condition to be completely removed with almost no loss of juice.

Many experiments have been made (as will be seen by reference to page 316) for the purpose of learning at what temperature the lime should be added; and there appears to be no difference whether the lime is added to the juice at the ordinary temperature, or at any point under boiling. Owing to the possibility that the acids of the juice may cause the inversion of some of the sugar after the heating is begun, also in order to have ample time for adding the proper amount of lime before the boiling point is reached, it would seem to be desirable to add the lime as soon as possible after turning on the heat.

If an excess of lime is used, it will result in giving a darker color to the juice and to the syrup produced from it.

After having withdrawn the heat, the contents of the defecator are left at rest for from fifteen to twenty minutes, after which the scum may be carefully removed by a large skimmer, pierced with holes not over one-sixteenth of an inch in diameter; and this scum may be emptied into a gutter, upon one side of the defecator, by which it may run to the scum tank for future treatment.

The disposition of the skimmings will be discussed in the chapter on waste products, page 376. It will be found possible to remove almost every particle of scum in this manner, with but little loss of juice.

It is, with many, the practice to fill the defecator with the fresh juice, and then, after liming, bring it to the boiling point, and letting it boil gently, to sweep off the dense scum into a gutter attached to one side of the defecator, which is about four inches lower than the other three, so that whatever boils over shall be saved with the scum. This method is very wasteful, unless the scum is treated by filters to recover the juice lost, and is uneconomical, since it necessitates the filtering of very much more juice. It is a practice, in short, having nothing to commend it.

After skimming the contents of the defecator, it will be found, when the juice has fallen to a temperature of about 85°C. (185°F.), that the sediment has quite subsided, and occupies a depth of about two inches, the defecated juice above being perfectly clear and almost colorless, resembling a very pale sherry.

Such a result may be regarded as an indication of a successful defecation. Too little lime will be indicated by a turbid, cloudy liquor; and too much lime by a bright, clear juice, but darker color.

For the purpose of watching the progress of the precipitation of the sediment, and to learn when it is completed, it is convenient to have

a strong open glass tube, cut square off at each end, with an interior diameter of not over one-quarter of an inch. By carefully thrusting this to the bottom of the defecator, while holding it upright, and then after placing the finger firmly over the opened upper end and withdrawing carefully, a good section may be taken out of the defecator for inspection.

By having a series of cocks up and down the defecator at intervals of six or eight inches, it will be possible to draw off the clear juice from above the sediment, without waiting for its complete subsidence. The last cock should be an inch or an inch and a half from the bottom of the defecator, so that nearly all the juice may be drawn off without disturbing the sediment. Finally, the sediment itself is drawn off, by a cock in the lower part of the pan, which empties into a tank, the same or similar to the one for the scum, and the juice remaining in it may be secured by the bag filters or filter press.

By proceeding as above, it will be found practicable to secure the juice so clear as to permit its going at once to the evaporators, without being passed through any filter.

It has been the practice of many to draw the contents of the defecator immediately after skimming into settling tanks, where it is allowed to stand, as in the defecator; but it would seem desirable to have two or more defecators in use, so that they may take the place of settling tanks, and thus avoid the necessity of disturbing the juice during the subsidence of the sediment.

The plates will illustrate some of the several forms of defecators in use among sugar makers. See page 344.

OTHER AGENTS IN DEFECATION.

Effect of adding Water to the Juice during Defecation.

It may frequently happen, where the specific gravity of the juice is very high, from 1.075 to 1.090 (10° to 12° Beaumé), that, owing to this great density, the precipitate will not subside in the process of defecation, but will remain permanently suspended in the defecated juice. As it has been found upon trial, that, during the process of evaporation, this suspended matter was but partially brought to the surface as scum, and remained in the syrup, giving it a disagreeble appearance and taste, the experiment was made of diluting the juice after defecation by adding buckets of cold water directly after having removed the scum, and it was in every case found entirely satisfactory, causing the sediment to subside, and only necessitating the removal of this additional amount of water by evaporation.

Fourteen experiments were made, with an average of about 1,000

pounds of juice in each experiment, and different quantities of water were added, according to the density of the juice operated upon, varying from 10 to 35 per cent of the weight of the juice. In each case, the actual amount of sucrose and glucose present in the juice, and in the syrup obtained from the juice, was determined, and it was found, as an average of the fourteen experiments, that 90.4 per cent of the sucrose, and 88.0 per cent of the glucose, in the juices was recovered in the syrup—an amount of loss easily accounted for as indispensable in the necessary operations of manufacture.

Action of Lime upon the Glucose and Sucrose in Juices during Evaporation.

The following experiments were made, for the purpose of determining the effect of lime upon the sucrose and glucose in juices during evaporation, and will be studied with much interest by the sugar maker, as the results are, in some respects, surprising and of very great practical importance.

In the three sets of experiments, the results of which are given below, a solution of the strength given, equal in volume to 2,000 c. c., was placed in a large glass flask, and boiled in the open air over a gas stove for several hours.

Samples were taken at first, and at intervals during the process of boiling, and subjected to analysis. These samples were always taken just after the evaporated water had been replaced. The amount evaporated was determined by graduations upon the side of the flask; but, on account of the width of the column of liquid, it was difficult always to bring the solution back to the exact volume of the original, and, doubtless, some of the irregularities recorded below are due to this cause.

In each sample taken for analysis, the acidity or alkalinity, glucose and sucrose, were determined, the sugars being estimated by the same methods used in the analysis of juices.

In the series of experiments No. 1, no color appeared until sample No. 5 was taken, at the end of four and a half hours' boiling; the solution then became gradually darker, until sample No. 8 was taken, which was very much darker than sample No. 7.

No. 9 was still much darker, and then the coloration proceeded gradually until the end, sample No. 11 being of a sherry-wine color.

In the series of experiments No. 2, there was a gradual darkening of color till the end, sample No. 24 in this series resembling a dark whisky in color.

In the series No. 3, sample No. 1 was colorless; No. 2 was dark-brown, with a heavy precipitate. The color gradually darkened to the end. Sample No. 12 was a very dark-red wine color.

EFFECT OF LIME DURING EVAPORATION OF JUICES.

Experiment No. 1.—No Lime added to Solution.

No. of sample.	Time of boiling.	Ca (H O)² in 1,000 c. c.	Ca (H O)² required to neutralize 1,000 c. c.	Glucose in 100 c. c.	Sucrose in 100 c. c.	Gain in glucose.	Loss in sucrose.
	Hours.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Per cent.*	*Per cent.*
1	0	....	.004	2.24	14.31	....	....
2	2	....	.005	2.88	14.22	29	1
3	2½	....	.002	3.19	13.69	42	4
4	3	....	.002	3.55	13.00	58	9
5	4½	....	.004	4.73	12.13	111	15
6	7½	....	.002	8.83	8.35	294	42
7	10½	....	.009	12.13	5.53	442	61
8	13½	....	.020	15.67	1.57	600	89
9	16½	....	.022	17.20	1.52	668	89
10	18	....	.029	18.70	.81	735	94
11	22	....	.032	20.30	.00	806	100

Experiment No. 2.—A Little Lime added to Solution.

No. of sample.	Time of boiling.	Ca (H O)² in 1,000 c. c.	Ca (H O)² required to neutralize 1,000 c. c.	Glucose in 100 c. c.	Sucrose in 100 c. c.	Gain in glucose.	Loss in sucrose.
1	0	.067	....	2.34	20.29	....	....
2	½	.041	....	2.38	19.61	2	3
3	1	.033	....	2.43	19.57	4	4
4	1½	.031	....	2.57	19.58	10	3
5	2	.031	....	2.66	18.16	14	11
6	2½	.023	....	2.86	18.37	22	9
7	4	.014	....	3.44	17.88	47	12
8	5½	.011	....	3.90	17.22	67	15
9	5½	.014	....	3.95	16.68	69	18
10	7	.007	....	5.08	14.94	117	26
11	8½	.005	....	6.40	14.26	174	30
12	10½	....	.005	7.95	12.20	240	40
13	11½	....	.013	10.28	10.45	339	49
14	13	....	.020	12.50	8.66	434	57
15	15	....	.025	14.90	7.75	537	62
16	15½	....	.029	15.68	5.18	570	74
17	16	....	.034	16.73	4.44	615	78
18	17½	....	.036	17.28	2.38	638	88
19	20½	....	.050	18.83	1.82	705	91
20	23½	....	.072	20.73	0.38	786	98
21	26½	....	.063	20.30	0.40	768	98
22	29½	....	.104	20.60	—0.30	780	101
23	31	....	.115	21.80	—0.78	832	104
24	5	....	.115	21.65	—0.05	825	100

Experiment No. 3—Much Lime added to Solution.

No. of sample.	Time of boiling.	Ca (H O)² in 1,000 c. c.	Ca (H O)² required to neutralize 1,000 c. c.	Glucose in 100 c. c.	Sucrose in 100 c. c.	Gain in glucose.	Loss in sucrose.
1	0	0.000	....	2.31	14.76	....	....
2	0	4.003	....	.28	6.60	87.9	55.3
3	½	3.110	....	.10	6.56	95.7	55.6
4	1½	....	....	.07	6.66	97.0	54.9
5	3	2.563	....	.05	6.68	97.8	54.7
6	4½	2.577	....	.01	7.43	99.6	49.7
7	7½	2.563	....	.02	7.17	99.1	51.4
8	10½	2.520	....	.04	6.93	98.3	53.1
9	13½	2.549	....	.04	6.63	98.3	55.1
10	16½	1.541	....	.02	6.94	99.1	53.0
11	18	1.321	....	.02	6.77	99.1	54.0
12	22	1.226	....	.07	7.18	97.0	51.4

In considering the results of the above experiments, it will be observed that, in the series of the first experiment, where no lime was added, there was a continuous increase in the amount of glucose, and a decrease in the amount of sucrose, as the result of the boiling. After an interval of two hours, the actual loss in sucrose was only .09 gram. while the increase in the glucose was .64 gram.; but the .09 gram. sucrose would furnish, by its inversion, only .0947 + gram. of glucose, which is much less than the gain shown. It is probable that the commercial glucose was composed of other compounds largely intermediate between starch and glucose—compounds which would have no effect upon Fehling's solution, but which, by boiling, were readily converted into glucose, or some copper-reducing compound.

The general result, however, is manifest, viz : the rapid and continuous inversion of the sucrose present, until, at the close of the experiment, sample 11 showed no sucrose present, and an increase of over 800 per cent in the amount of glucose.

The increase in the acidity of the solution is noticeable, amounting to 800 per cent, and determined by the amount of lime required to neutralize the solution, 1,000 c. c. requiring at the beginning only .004 gram., but at the end of the experiment .032 gram. This increase was by no means constant, but was most marked after about eleven hours' boiling.

In the series of experiments No. 2, where a small amount of lime was added to the solution, the solution, at first alkaline, becomes, after about nine hours' boiling, slightly acid, and this acidity increases steadily to the end of the experiment, until, at the end of thirty-five hours' boiling, the amount of lime necessary to restore neutrality is twice as much as that originally added to the solution. After the solution had become distinctly acid, the inversion of the sugar became much more rapid.

Also, during the earlier periods of this experiment the amount of glucose increases but slightly, although there is a gradual decrease of sucrose. This is doubtless due to the fact, that the action of the lime is mainly exerted in the destruction of glucose, as has been shown in my reports to be true in experiments in sugar making from sorghum and maize juices.

The practical point, however, to be observed is, that, so long as the solution remained distinctly alkaline, there was but very slight loss in sugar and slight increase in glucose, two desirable conditions in the economical production of sugar from sorghum. And so soon as this alkalinity was destroyed, through the formation of acid products during the boiling, the inversion of sugar became rapid, and the accumulation

of glucose very marked. These results are, obviously, most undesirable in sugar making. The conclusion thus far would be, that the solution should, during boiling, be kept slightly alkaline.

In the series of Experiments, No. 3, where a larger quantity of lime was added to the solution, its effect at the outset was to remove from the solution as a precipitate about half of the sugar, and the remainder during eighteen hours of boiling was found to be unchanged in amount; on the other hand, the action of this excess of lime upon the glucose was very marked, effecting practically its destruction within two hours, and producing from the glucose other compounds of high color, which dissolved in the liquid and gave it a deep wine-red color.

It would appear from this last series of experiments that an excess of lime has no action upon cane sugar, as has already been established, and that its effect is to diminish rapidly the glucose present, and darken the solution.

The above experiments corroborate the results of practical working with large quantities of juice, and explain fully the loss of the glucose shown to be present in the fresh juices, but which was found in comparatively small quantity in the syrups manufactured from these juices.

Effect on Juice of Standing after Defecation.

In the daily work at the Department of Agriculture, it became frequently desirable to keep a supply of juice over night; and it was found that, after defecating as usual with lime and heat, the juice could remain in the defecator without suffering any detriment. As this is a matter of considerable practical importance in working up large quantities of juice, especially if the work is not carried on through the night, by enabling one to have a fresh lot of juice for the evaporator early in the morning, the following results of these experiments are given, including the analysis of juice before defecation and after standing over night in the defecator, of the syrups produced, and the percentage of sugar present in the juice and obtained in the syrup. It will be seen that the results show no effects fairly to be charged against this mode of procedure.

EFFECT OF JUICE ON STANDING AFTER DEFECATION.

Experiment number.	Pounds juice.	Time in defecator.	Pounds water added.	Per cent sucrose by polarization.	Per cent of glucose in syrup.	Per cent of sucrose in syrup.	Per cent of solids not sugar in syrup.
1	627 5	17 hours....	105	30 91	16.15	45.32	12 98
2	770.5	14.5 hours....	....	32 40	28 00	38 05	13 45
3	682	15.3 hours....	126	36 05	18 00	38 00	15.40
4	1,162.5	15.5 hours....	....	24 71	37.00	30.50	5 70
5	·746	16 hours....	....	35 23	34 40	36.39	12 21
6	728.5	14 hours....	....	55.40	6.50	59.85	17.45

Experiment number.	Analysis of juice.			Analysis of juice after defecation.			Per cent sucrose of juice in syrup.	Per cent glucose of juice in syrup.
	Per cent of glucose.	Per cent of sucrose.	Per cent of solids not sugar.	Per cent of glucose.	Per cent of sucrose.	Per cent of solids not sugar.		
1	....	....	....	....	....	....	98 7	96 5
2	....	....	....	....	....	....	98 5	78 3
2	....	....	....	....	....	....	75 5	71 8
4	7.10	7 26	1.19	8 40	7.43	1 72	80 1	99 4
5	6 01	6 95	1 59	6 91	7.12	2 05	76.0	83 1
6	1.79	14.29	3.64	1.84	14.73	2 60	69.9	69 7

It will be seen that in those juices which were analyzed before defecation, defecated and allowed to stand on an average of 15 hours, there was no loss of sucrose sustained, and that the average of the 6 experiments showed that 83.1 per cent of both the sucrose and glucose present in the juice was recovered in the syrup.

Use of Clay in Defecation.

In order to effect the more rapid and complete subsidence of the lime precipitate produced by defecation, it has been the practice of some sugar makers to mix, with the cream of lime, clay or finely pulverized gypsum (plaster), whiting, sulphate of baryta, etc., the object being to entangle in the flocculent precipitate this heavier material, and thus cause its more rapid subsidence. To accomplish this, the clay or other material, is stirred up into a thin cream with water, and mixed in with the cream of lime in proportion so that for each 100 gallons of juice to be defecated there shall be added along with the lime about a gallon of the clay or other cream. After skimming, as usual, the contents of the defecator are allowed to stand, to be drawn off as in the

ordinary defecation, or the defecator is at once emptied into a subsiding tank where the defecated juice is left until complete subsidence is effected, when the juice is drawn off for evaporation as usual.

Superphosphate of Lime.

The use of this compound has been very highly commended in defecation. It is added in solution to the juice just before the neutralization with lime. The superphosphate of lime forms, with some of the lime which is added in liming the juice, an insoluble phosphate of lime, which is readily precipitated, carrying with it the lighter sediment which would the more slowly settle. As superphosphate of lime of a high grade may now be readily obtained in the market, a solution of it in water may be easily prepared for use.

Alumina in Defecation.

The use of alumina, either as the sulphate, phosphate, hydrate, or in other forms, depends upon its property of forming, when precipitated from its solutions, a gelatinous mass, which mechanically entangles the impurities rendered insoluble by heat and lime, and in its subsidence carrying such impurities along with it. Its use in clarifying water for the purpose of the laundry, depends upon this same principle.

The various forms in which it is used, are the sulphate (porous alum so-called), and a mixture patented in England, over a half century ago, known as "Howard's Finings," which, patented in England, October 31st, 1812, by Edward Charles Howard, the inventor of the Vacuum Pan, was largely used in the refining of sugar. Similar mixtures are largely used in the United States. The objection to the use of alum is, that by it compounds of potash would be introduced into the juice, the presence of which are very injurious.

Howard's Finings may be prepared, by boiling in a convenient vessel thin cream of lime, until, after a few minutes, a sort of lime curd is formed. Then, for each 100 gallons of juice, 2½ pounds of alum are dissolved in 6 gallons of water, and 3 ounces of whiting, finely pulverized, is added to the alum solution, the mixture being stirred until all effervescence ceases. It is then allowed to settle, and the clear liquor is poured off. To the residue from which the liquor has been drawn, enough of the curdy lime previously prepared is added, with thorough intermixture, until a slip of yellow turmeric paper is just turned a slight brownish red when placed in the mixture. Then, after letting the mixture settle and pouring off any supernatant liquid, it is

placed upon a blanket filter, until it has so far dried as to begin to crack, when it may be kept for use in defecation.

The method of using this is, to mix it up into a cream and apply in the amount above stated, using for each 100 gallons as much of the finings as would be made from $2\frac{1}{2}$ pounds of alum.

The details of the process as given, in "Sugar Growing and Refining," are as follows:

The juice is strained before entering the defecator, and is then gently heated; to each 100 gallons of juice, 2 ounces (more is necessary with sorghum juice) of finely sifted quick-lime are made into a cream with water and added to the contents of the defecator, with thorough stirring, and the heat is increased to 82° C. (180° F.), until a thick crust forms on the surface and shows a disposition to crack. This may take 15 to 20 minutes after the addition of the lime; if it is very slow in forming, the heat may be raised to 93° C. (200° F.), but not beyond. When the crust of scum has formed and shows signs of cracking, the heat is withdrawn, and the juice is allowed to stand for 10 minutes, when it is drawn off through a fine strainer into a second vessel, called the precipitator. Here, again, the juice is heated up to the boiling point, but is not allowed to boil, and the scum is removed as fast as it forms. The juice is then boiled for 10 or 15 minutes, with constant skimming, and then the "finings" are added, with stirring, and the boiling is continued for 2 or 3 minutes more, when the juice is quickly run off into a subsiding tank, and allowed to rest for from 2 to 6 hours. It is generally then passed through charcoal filters, and thence goes to the evaporators.

It will be seen that the "finings" are composed of a mixture of sulphate of lime, alumina, and lime, and that, in short, this mixture is used after the removal of the scum of the ordinary lime defecation, to effect the more complete subsidence of the precipitate, which it does mechanically.

Porous alum, an impure sulphate of alumina, prepared by dissolving 4 ounces of the salt in a gallon of water, and, after allowing it to settle, pouring off the clear solution for use, is used in a similar way, for the clarification of defecated juices and semi-syrups.

Basic alum and *defecating compound* are two forms of alumina recommended by certain manufacturers. They are prepared, being practically identical, by adding to a solution of porous alum (crude alumina sulphate) a solution of sal-soda in water, until a slight permanent precipitate is produced.

The materials are used in connection with the cream of lime in ordinary defecation, and also with the clay cream already referred to.

A solution of water glass, basic silicate of soda, has been recommended—the gelatinous silica which is produced mechanically carrying down the impurities.

The principal objection to several of these preparations is the intro-

duction into the syrup of the soluble salts of potash or soda, and their use is not to be advised under any circumstances, unless solely by way of experiment. They are nearly all based upon the principle of Howard's Finings, for which they are a very poor substitute.

The use of sulphate of alumina for the removal of the potash present in the juices is, however, a most important matter, and is largely used in beet sugar manufactories and the refining of raw sugars, the potash being crystallized out as alum.

Lime-Sucrate Defecation.

In 1865, Boivin and Loiseau, of Paris, invented a process for the refining of raw sugars and the defecation of juices, by a process which, although complicated and requiring careful supervision, appears to have given excellent results. It is known as the lime-sucrate process, and the general procedure is as follows:

The freshly expressed juice is received into a tank, where it is agitated with cream of lime, the amount of which is equal to from 1 to 2 per cent of the juice. In this form, the juice will remain unchanged, and may be kept even for weeks, if desired.

When thoroughly agitated, the limed juice is treated with carbonic acid (obtained from the lime-kiln or coal furnace) in large tanks, which, owing to the frothing up of the juice in this operation, are filled to only one-fourth or one-fifth their capacity, and by means of revolving stirrers, it is kept in agitation during this process.

When the frothing ceases, the addition of carbonic acid is discontinued, and a portion of the juice is now tested by boiling for a few minutes and filtering. If the filtrate is of a pale straw color, and the precipitate upon the filter is not too gelatinous, indicating that not enough carbonic acid has been added, or too granular, showing that too much has been added (in the latter case, the filtered juice would be of a darker color), the operation is successful.

The object aimed at is to introduce sufficient carbonic acid to nearly precipitate the lime present, and yet to leave enough in combination with sugar in the form of sucrate of hydro-carbonate of lime, that, in the boiling of the juice, the flocculent precipitate produced may carry down the impurities of the juice. This, then, is the critical point of the whole operation. When it is found that the lime remaining dissolved in the juice is the right amount, the juice is boiled rapidly for a few minutes, and a pricipitate is thrown down containing nearly all the impurities of the juice.

It is now filtered by means of filter presses, and the juice, which, after filtering, should be of a light straw color, is again treated with

carbonic acid, to remove the lime which remains and which was not thrown down by the first treatment with carbonic acid nor by the boiling. It is then boiled, passed through bag filters, after having stood in the subsiding tanks for the subsidence of the carbonate of lime, and is ready for concentration. In expert hands, the process is most highly commended. Details may be found in "Sugar Growing and Refining."

SULPHUROUS ACID AND SULPHITES IN DEFECATION.

The employment of this re-agent in the defecation of saccharine juices was suggested by Proust, in 1810, and has been very general, and the results attending its use seem to justify it. This gas is the product of burning sulphur, and is readily made available by burning sulphur in such a way that the products of the combustion may be drawn from the furnace and brought in contact directly with the juice, or with water, in both of which the gas is very soluble.

The bleaching properties of sulphurous acid are well known; and it is, owing to its tendency to unite with oxygen to form sulphuric acid, one of the most powerful deoxidizing or reducing agents. It is also, by some, regarded as an antiseptic (preservative), and as a disinfectant; but whatever action it may have in this way is probably due to its removal of the oxygen of the air, and the destruction of the products of decomposition by its reducing power.

It will readily dissolve in water, one volume of water at 27° C. (81° F.) dissolving about 30 volumes of the gas, or at 21° (70° F.) 38 volumes, and at 16° C. (61° F.) 45 volumes; so that it may, by being dissolved in water, be easily prepared and kept for use, the only precaution necessary being to keep it in closely corked bottles, or casks, so as to exclude the air, the oxygen of which will unite with it, and, in time, convert it entirely into sulphuric acid, a substance which exercises the most injurious action upon sugar by converting it into glucose.

Sulphurous acid may be readily prepared by the reduction of sulphuric acid (oil of vitriol) by means of charcoal, according to the following re-action:

$$\begin{array}{ccccccccc} \text{Sulphuric acid} & + & \text{Charcoal} & = & \text{Water} & + & \text{Carbonic acid} & + & \text{Sulphurous acid.} \\ 2(H_2SO_4) & + & C & = & 2H_2O & + & CO_2 & + & 2SO_2 \end{array}$$

Or, by weight, as follows;

$$\begin{array}{ccccccccc} \text{Sulphuric acid} & + & \text{Charcoal} & = & \text{Water} & + & \text{Carbonic acid} & + & \text{Sulphurous acid.} \\ \text{196 parts} & + & \text{12 parts} & = & \text{36 parts} & + & \text{44 parts} & + & \text{128 parts.} \end{array}$$

The apparatus used by the author for making this solution of the gas, consisted of a small-sized hot water tank for kitchen range, about forty inches long and ten inches diameter. Into this, powdered charcoal and oil of vitriol were put, and the sulphurous gas passed through iron gas pipes into a wash bottle containing oil of vitriol, and from thence into a barrel nearly filled with water. A safety tube was connected with the wash bottle, to prevent any possible rushing back of the water into the generator in case of the withdrawal of the heat. By this apparatus, a barrel or two of the solution may be made in a short time, and at an expense of not over seventy-five cents per barrel. For two barrels of the solution there would be required seventy-five pounds of oil of vitriol and seven pounds of powdered charcoal.

When the sulphurous acid is for immediate use, and when steam is used, the use of the sulphur box is the most convenient form. This may be easily constructed by anybody, and consists of a wooden box three or four feet high and from two to three feet square, with ten or twelve partitions, slightly inclined, and reaching nearly across the box from side to side, so that the juice, entering the box at the upper end, flows across the upper partition and, falling upon the second, flows back under the place of entering, and then falls upon the third partition, and thus, running back and forth over the partitions, and falling from each in a thin sheet, is thoroughly exposed to the fumes of sulphurous acid, which enter by a pipe, placed between the second and third partitions from the bottom, from a small furnace of iron near the box, to which the pipe acts as a chimney. Into this furnace small bits of roll brimstone, or flowers of sulphur, are placed from time to time, the burning of which produces the sulphurous acid. A sliding door to the furnace determines the amount of air admitted to the burning sulphur, and therefore regulates the rapidity of the combustion and the amount of sulphurous acid produced. The draught to the furnace is produced by a steam-pipe, which enters the sulphur box two or three partitions above that where the pipe from the sulphur furnace enters.

Generally, it is found that from two to six ounces of sulphur are sufficient for five hundred gallons of juice; so that, after having ascertained the amount of sulphur necessary, the draft to the furnace may be so adjusted as to give the requisite quantity.

Six ounces of sulphur will give gas enough to saturate four gallons of water at 27°C. (81°F.); so that, if the solution is used instead of the gas direct, the relative amount to be used may be easily ascertained.

The treatment of the juice with sulphurous acid, and then leaving it from six to ten hours in the settling tanks, has already been mentioned as being successful in the removal of a large amount of impurities;

and it is claimed that the sulphurous acid renders certain of these impurities of the juice insoluble, and thus effects their removal in the settling tanks. This is a matter requiring and deserving very careful investigation.

The general use of sulphurous acid is, however, in the sulphur box, where the freshly expressed juice, on its way to the storage tank and immediately previous to its defecation with lime, is charged with this gas; or the juice, after defecation and the separation of scum and sediment, is treated with the sulphurous acid, until the juice, which had been rendered slightly alkaline by the lime, is rendered acid again.

The addition, at this stage, changes the color of the defecated juice, bleaching the color which still remains, and greatly improving the appearance of the juice. Any excess of the acid which may be added is removed readily during the evaporation, since the gas is very volatile.

Any small quantity of sulphuric acid which may be present in the sulphurous acid used, will be rendered harmless by the slight excess of lime present, and will form the insoluble sulphate of lime, which may be removed as sediment or skimmings in the process of manufacture. So far as the results of the author's experiments go, there appears to be no choice in the two methods, above described, of using the sulphurous acid; and, indeed, it seems that the advantages claimed for it are greatly over-estimated. It is certain that, by prompt working of the cane, the results, without its use, have proved as satisfactory as with it. In case of delay in working up the juice, it would appear that the use of the gas as a temporary antiseptic is beneficial. It is probably true that, by its oxidation, it forms sulphuric acid, which, with the soluble potash salts present in the juices and retained by the syrup, forms the comparatively insoluble sulphate of potash, a salt which has been found not to retard the crystallization of the sugar in the syrup.

At the large sugar factory at Aba-el-Wakf, in Egypt, the juice was first treated with sulphurous acid previous to the liming, and the results showed excellent returns in sugar; but it does not appear that the good results were due any more to the use of sulphurous acid, than to the many improved appliances of this famous mill. It must be remembered, that the bleaching by sulphurous acid is only temporary, the color being only masked, but not destroyed; so that the apparent action of this re-agent is very deceptive, and not comparable with that of bone-black, which completely removes the color from the juice or syrup.

Bisulphite of Lime.

This compound, so called, exists neither in theory nor in practice; but the name has long been applied to the salt produced by the union of lime and sulphurous acid, the only chemical compound of which is the sulphite of lime known commercially as the bisulphite. It may be had in quantity at a few cents (five to seven) per pound, and contains about 30 per cent of sulphurous acid (if chemically pure, it should contain 53⅓ per cent), and, owing to its comparatively low price and great convenience in handling, is the most available form in which sulphurous acid may be used by the sugar manufacturer. This salt is practically insoluble in water; but is soluble in a solution of sulphurous acid, and is said to exist in such solution as the bisulphite, which in effect it is, and in such solution it is largely prepared and used by sugar makers. In using this re-agent in defecation, the acid of the juice will liberate the sulphurous acid, and give practically the same results as by the use of the gas.

Many experiments were made with a mixture of slaked lime and commercial sulphite, using the same in precisely the manner of using the lime in defecation. The mixture contained 15½ per cent of sulphurous acid, 50 per cent of dry slaked lime, and the remainder moisture, sulphate of lime, and other impurities.

For comparison, certain experiments were made with the calcium sulphite alone, and the results are given at the end of this chapter.

EXPERIMENTS IN DEFECATION.

During the season of 1882, there were made, in all, seventy-eight experiments in defecation, using the following re-agents: Hydrate of lime, calcium sulphite, and a mixture of these two. The results of these experiments are given in detail in the following tables:

In table A, is given the variety of sorghum used in each experiment; and it will be seen that the new African varieties were used in eight of the experiments, the new varieties from India in five experiments, and different varieties grown in this country for the remaining sixty-five experiments. In each case, for purpose of comparison, the analysis of the juices is given. In most cases, each sample of juice analyzed was used for several experiments in defecation, and the syrups, in each case, were also analyzed.

In Table B, the details of each experiment is given, and the character of the different syrups produced.

In Table C, are given details of fourteen experiments in defecation

of the juice and manufacture of syrup and sugar, which were carried through quantitatively.

By reference to Table A, it will be seen that the average composition of the juices in the seventy-eight experiments, and of the syrups made from them, is as follows:

	Juices.	Syrups.
Per cent sucrose in total solids	76.06	81.88
Per cent glucose in total solids	8.38	7.56
Per cent solids, not sugar, in total solids	15 56	10 58
Per cent available sugar in total solids	52.13	63.81

From the above it appears, that, in the preparation of these syrups, there was an increase of 7.65 per cent in the relative amounts of sucrose, and of 22.45 per cent in the relative amounts of available sugar, over the relative amounts present in the juices from which the syrups were made, while there was a relative decrease of 9.79 per cent in the glucose and of 39.20 per cent in the solids not sugar.

As it is, for the purpose of sugar production, most desirable to decrease, as much as possible, the relative amounts of glucose and other solids, not sugar, in the syrups (or, what is equivalent, to increase the relative amount of sugar in a syrup), the above results are obviously very satisfactory. But these results do not show what proportion of the sugar present in the juice was actually recovered in the several syrups.

In table C, it will be seen that, as an average of the fourteen experiments, there was found, of each constituent in the several juices, and in the syrups made from them, the following parts, by weight:

	In juices.	In syrups.
Sucrose	1,151	1,036
Glucose	149	108
Solids, not sugar	224	128
Available sugar	778	800

In other words, there was a loss of 10 per cent of the sucrose, of 27.52 per cent of the glucose, and of 42.86 per cent of the solids not sugar, and a gain of 2.83 per cent in the amount of available sugar present in these syrups, as compared with the actual amounts present in the juices from which they were made.

The recovery, then, of 90 per cent of the amount of sugar present in the juices of sorghums, and an actual increase in the amount of available sugar, is conclusive evidence that these juices may be manip-

ulated with as great economy as are the juices of sugar-cane, if only due care is exercised.

Of course, this loss of 10 per cent of the sugar is due to such portions as are lost in the scum and sediments of defecation, and in the skimming necessary during the evaporation to syrup. As these experiments were necessarily upon a very small scale, using rarely, for each experiment, more than a quart of juice (since, as has been mentioned, our entire plat of sorghum, of sixty-four varieties, only equaled two-ninths of an acre), it is fair to presume that the losses sustained by working such small amounts were much greater in proportion than would be necessary when working with larger quantities.

By reference to page 61 of the Annual Report for 1879, it was said, as the result of certain experiments that year:

We may hope, then, to secure in syrup 90 per cent of the crystallizable sugar present in the juices operated upon.

And in the Annual Report for 1881–'82, page 500, it is said of the experiments made in 1881:

The results show, that, in the forty experiments made, the amount of sucrose recovered in the syrups, was 87.5 per cent of the actual amount in the juice.

There remains only to speak of the character of the syrups produced in the seventy-eight experiments following. In Table B, a column is given, which describes the physical character of the several syrups made, and, as will be seen, in nearly every case, crystals of sugar were present, while, in a very large number, the syrup was a semi-solid mass of sugar and molasses.

In the fourteen experiments which were made quantitatively, eleven of the syrups were a solid mass of crystals; in two of them, two-thirds of the syrups was semi-solid with sugar; and in the remaining sample, the syrup contained a few crystals of sugar, but the analysis showed that this one had not been evaporated quite to the point of good crystallization. All of the seventy-eight experiments were made by open pan evaporation.

As evidence of the character of the juices used in these fourteen experiments, it will be seen that their average analysis was:

Specific gravity, 1.0786.

	Per cent.
Sucrose	13.646
Glucose	1.696
Solids not sugar	2.632
Polarization	13.048
Available sugar	9.298

And the per cent of syrup made from the juices averaged 20.85.

The average composition of the juices used in the seventy-eight experiments, was as follows:

Specific gravity, 1.077.

	Per cent.
Sucrose	13.55
Glucose	1.15
Solids not sugar	2.77
Polarization	13.28
Available sugar	9.29

TABLE A.—EXPERIMENTS

No. of Analysis.	Variety.	Development.	Jui[ce] Per cent. of juice.	Specific gravity.	Per cent of glucose.	Per cent of sucrose.	Per cent of solids not sugar.
605	White Liberian	Seed hard, sucker in dough	49 95	1 068	1 14	12 11	2 77
606	Early Amber	" "	63 61	1 070	1 00	13 18	2.60
707	Mixed juices from rows 25,33,34			1.072	1.53	12.98	1.16
760	West India	Seed hard, sucker in dough	57.92	1.078	2.04	13.62	2.40
773	Red sorgho	" "	59.01	1.072	1.27	12.34	3.17
793	West India	" "	59.37	1.076	2.04	13.14	2.35
809	"	" "	59.85	1.074	1.73	12.51	2.78 Lost
821	"	" "	59.15	1.078	1.72	13.55	2.90
834	"	Seed hard, sucker in hard dough	58.28	1.079	1.85	13.47	2.88
851	"	" "	58.64	1.079	2.12	13.28	2.69
866	"	" "	59.24	1.074	2.29	12.09	2.75
882	"	" "	57.46	1.078	2.06	12.87	3.27
895	"	" "	58.62	1.074	2.09	12.34	2.68
910	New variety, E. Link	Seed hard, sucker in dough	58.72	1 079	.89	14.78	2.88
970	" "	" "	63.01	1.082	.62	15.17	3.28
983	" "	Seed hard, sucker in hard dough	53.63	1.082	1.73	14.20	3.18
995	" "	" "	53 68	1.083	.85	14 64	3.61
1008	" "	" "	57.93	1.072	1.50	12.62	2.50
1021	Standard, T. O. Harrell	Seed hard, sucker hard	51.63	1.080	.39	16 17	2.15
1045	" "	" "	52.36	1.080	.52	15.14	3.01

IN DEFECATION.

CE.						SYRUP.											
Polarization, per cent.	Per cent of available sugar.	Per cent of sucrose in total solids.	Per cent of glucose in total solids.	Per cent of solids not sugar in total solids.	Per cent of available sugar in total solids.	No of analysis.	Experiment.	Specific gravity.	Per cent of glucose.	Per cent of sucrose.	Per cent of solids not sugar.	Polarization, per cent.	Per cent of available sugar.	Per cent of sucrose in total solids.	Per cent of glucose in total solids.	Per cent of solids not sugar in total solids.	Per cent of available sugar in total solids.
11.81	8.20	75.59	7 12	17.29	51.18	623	A B	1.072	9 40	48.45	12.95	48.60	26.10	68.43	13.28	18.29	36.86
12.64	9.58	78.54	5.96	15.49	57.09	624	A B	1.070	5.65	52.30	6.45	52.41	40.20	81 21	8.77	10.02	62.42
12.44	10.29	82.83	9 76	7.40	65.67	708	......	1.070	11 30	46.74	5.20	44 31	30 24	73 91	17.87	8.22	47 82
						761	A	1.066	7 34	50.62	5.84	52.50	37.44	79.34	11.50	9.15	58.69
12.93	9.18	75.42	11 29	13.29	50.84	762	B	1.070	6 10	47.03	10.15	50 87	30 78	74.32	9.62	16.04	48.66
						763	C	1 069	5.20	48.07	9.17	50.38	33.70	76.98	8.33	14.69	53.96
						778	A	1 076	4.00	54.34	8.70	54.43	41.64	81.06	5.96	12.98	62.02
						779	B	1 071	3.80	51.11	8.69	51.68	38.62	80 36	5.97	15.66	58.73
12.71	7 90	73.54	7.57	18.89	47.08	780	C	1 071	3.65	48.69	9 94	49 81	35.10	78.18	5.86	15.96	56.36
						781	D	1 072	4.35	51.16	8.69	51 84	38.12	79 69	6.77	13.54	59 38
						782	E	1 074	4 30	53.39	8.07	53 62	41.02	81 19	6.54	12 27	62.38
						794	A	1 071	6 25	49.64	9.19	52.16	34.20	76.28	9 60	14 12	52 56
12.57	8.75	74.96	11.64	13.41	49.91	795	B	1 073	6 50	51 49	7 87	52 81	37.12	78.18	9 87	11 95	56 36
						796	C	1 071	5.75	48 69	11.68	50.38	31 26	73.64	8 69	17 66	47.29
						810	A	1.072	6.85	52 87	6 76	55 57	39 26	79 53	10.30	10.17	59.06
12.52	8.00	73.50	10.16	16.33	47.01	811	B	1 068	6 75	50.59	6.70	53.22	37.14	79.00	10 54	10 46	58.00
						812	C	1 068	6.20	49.50	8 10	52 33	35 20	77 59	9 72	12 69	55.18
						813	D	1 064	6.05	46.98	6.93	48.84	34.00	78.35	10 09	11 56	56 70
						822	A	1.065	5 15	51 92	7.13	54.43	39 64	80 87	8 02	11 11	61 74
12.96	8.93	74.57	9.47	15.96	49.14	823	B	1 070	5.40	51 49	7.35	55 57	38 74	80 15	8 41	11 44	60 30
						824	C	1 069	5 05	51 06	7.25	53.78	38.76	80 59	7 97	11 44	61.18
						837	A	1 067	5 75	49.26	5 83	51 19	27 68	80.97	9 48	9 58	61.94
12.91	8.74	74.01	10.16	15.82	48.03	838	B	1.066	5 45	47.64	7.23	51.19	34.96	78 98	9 03	11 99	57.96
						839	C	1 070	5 30	48 74	9.84	49.90	33.60	76 29	8 30	15 40	52.29
						840	D	1.067	5.80	50.26	4 60	53 30	39.86	82 86	9 56	7 58	65.72
						852	A	1 068	6 25	48.97	7.10	53.14	35.62	78.58	10 03	11 39	57 16
12.85	8.47	73.41	11.72	14.87	46.82	853	B	1.070	6 30	51.02	6.28	53.95	38.44	80.22	9 90	9 88	60.44
						854	C	1 067	6.15	47.83	7.30	53 70	34.38	78 05	10 04	11 91	56.10
						855	D	1 069	6.55	58 76	7.33	52.81	44.88	80.89	9 02	10 09	61 78
						867	A	1 072	7.90	50.16	6 50	55.24	35.76	77 70	12.24	10.07	53.39
11.88	7.05	70 58	13.37	16.06	41.05	868	B	1.073	7 65	50 68	6 31	55.24	36.72	78 40	11.83	9 77	56 80
						869	C	1 067	6 95	47.55	6.13	52.49	34.42	78.36	11.45	10 18	56.73
						883	A	1 068	6.50	48.93	7.13	51.84	35.30	78.21	10 39	11 40	56 42
12.66	7.54	70.71	11.32	17.97	41.42	884	B	1 070	6.40	49 97	7.71	52.97	35.86	77.98	9.99	12 03	55.96
						885	C	1 071	6 45	51.16	8 03	53.70	36.68	77.94	9 83	12.23	55 88
						896	A	1 071	7.15	51.44	5.25	52.73	39.04	80 58	11.20	8 21	61.17
12.07	7.57	72.12	12.21	15.66	44.25	897	B	1.075	7 10	53 20	7.34	54.84	38.76	78.65	10.49	10 85	57 31
						898	C	1 069	6 90	48 83	8 27	52 41	33.66	76.30	10.78	12 92	52 60
						899	D	1.069	7 05	49.83	7.00	52.08	35.78	78.01	11.03	10 96	56 02
						911	A	1.067	2 90	55.01	4 25	54.92	47.86	88 50	4.65	6 85	77 00
14.69	11.01	79.68	4.80	15.53	59.35	912	B	1 074	3.10	58.43	6.83	60.75	48.50	85 47	4.54	9 99	70 94
						913	C	1.065	2 10	51·97	6.85	52 25	43.02	85.31	3.44	11.24	70.63
						914	D	1.064	2.65	56.95	.92	52.33	53.38	94.10	4 38	1 52	88.20
						971	A	1.068	2 05	55 15	7.00	56.86	46.10	85.91	3.19	10 90	71.82
15.06	11.27	79.55	3.25	17.20	59 10	972	B	1 069	2.05	57 43	5 24	56 70	50.14	88 74	3.17	8 09	76 48
						973	C	1.070	1.90	56 91	6.11	57.92	48.90	87.66	2.93	9 41	75 32
						984	A	1.067	2 30	53 68	6 82	55 24	44.56	85.48	3 66	10 86	70 90
15.19	9.29	74.31	9.05	16 64	48.62	985	B	1.072	2.45	57.81	6 66	58.64	48.70	86 39	3 66	9 95	72 78
						986	C	1.065	2 30	53 39	6 55	54.11	44.54	85.78	3 70	10 52	71.56
						996	A	1.070	2.15	56 91	5 38	56 70	48.38	88.13	3 39	8 48	76 26
14.95	9.98	75.85	4.41	19.74	51.70	997	B	1.070	2 15	56 72	6 09	56.70	47.48	87 14	3 36	9 52	74 26
						998	C	1 072	2 15	57 62	6 51	57.83	48.96	86 92	3 26	9 83	73 83
						1009	A	1.069	4 65	52 87	5 64	53.46	42.58	83.71	7 36	8 94	67.41
12.22	8.62	75.94	9.03	15.04	51.37	1010	B	1 066	4.60	50 83	6 53	51.03	39.70	82 04	7 42	10 54	64 08
						1011	C	1 069	4 95	52.11	4.54	51.68	42.62	84 59	8 03	7 37	69.19
						1022	A	1.081	1 40	64 03	7.37	66 42	55.26	87 95	1 92	10.18	75 90
15.44	11.63	81.08	2.09	16.83	62.16	1023	B	1.076	1 45	62.94	5.53	63 67	55.16	90 02	2 07	7 91	80.04
						1024	C	1.076	1.45	63.22	6 65	64.80	55.12	88 64	2 03	9 32	77.29
						1046	A	1.075	1.95	63.41	7.16	63.83	54.30	87 43	2 69	9 87	74.87
15.00	11.61	81.09	2.79	16.12	62.18	1047	B	1.075	1.65	63.70	6.57	64 80	55.48	88 57	2 29	9.13	77.15
						1048	C	1.075	1.85	64.36	7.67	64.64	54.84	87.11	2.50	10.38	74.23

TABLE A.—EXPERIMENTS

No. of analysis.	Variety.	Development.	JUI				
			Per cent of juice.	Specific gravity.	Per cent of glucose.	Per cent of sucrose.	Per cent of solids not sugar.
1058	Standard, T. O. Harrell........	Seed hard, sucker hard..........	48.70	1.078	.58	14.85	2.82
1071	New variety, R. Haswell......	" "	50.72	1.074	1.99	12.79	2.62
1084	Chinese Imphee, W. A. Sanders	" "	48.45	1.078	1.95	12.98	2.96
1093	Undendebule, Natal...........	" '	48.56	1.085	1.12	15.47	2.21
1102	" "	" "	50.67	1.079	1.33	13.90	2.72
1109	Hlogonde, A—Natal...........	" "	49.47	1.077	2.09	12.99	2.65
	Average..................	....	.....	1.077	1.148	13.55	2.79

IN DEFECATION.—*Continued.*

·CE.						SYRUP.												
Polarization, per cent.	Per cent of available sugar.	Per cent of sucrose in total solids.	Per cent of glucose in total solids.	Per cent of solids not sugar in total solids.	Per cent of available sugar in total solids.	No. of analysis.	Experiment.	Specific gravity.	Per cent of glucose.	Per cent of sucrose.	Per cent of solids not Sugar.	Polarization, per cent.	Per cent of available sugar.	Per cent of sucrose in total solids.	Per cent of glucose in total solids.	Per cent of solids not sugar in total solids.	Per cent of available sugar in total solids.
						1059	A	1.079	2.30	66.50	6.04	66.74	58.16	88.86	3.07	8.07	77.72
14.60	11.45	81.37	3.18	15.45	62 74	1060	B	1 077	2 20	65.55	4.81	65.93	58 54	90 34	3.03	6 63	80.68
						1061	C	1 078	2.40	67.55	3 77	67.31	61.38	91.63	3 25	5.11	82.27
						1072	A	1.080	7 35	57 71	7.38	58 81	42 98	79 67	10 14	10.18	59.35
11.95	8.18	73.50	11.44	15.06	47.00	1073	B	1.077	7 15	56.00	7.37	55.89	41 48	79.41	10.13	10.45	58.83
						1074	C	1.077	6 95	57.43	3 62	57.51	46·86	84 45	10 22	5 32	68.91
						1085	A	1.076	6.75	55 53	7 00	59 13	41.78	80 15	9.74	10.10	60.31
12.49	8.07	72.54	10 90	16 55	45 09	1086	B	1.076	6.70	54 63	8.87	60.75	39.06	77 82	9.54	12.63	55.65
						1087	C	1.076	6.90	54.15	9.75	60 35	37.50	76 48	9.75	13.77	52.96
						1094	A	1.080	4.05	62 46	4.01	64.64	54.40	88 57	5 74	5 68	77.35
14.61	12.14	82.29	5.96	11.75	64.58	1095	B	1 076	3 80	60.71	5 93	63 02	50.98	86 19	5 39	8.42	72 38
						1096	C	1.078	4.05	62 08	4 59	62 69	53.44	87 78	5.72	6 49	75 57
13.59	9.85	77.38	7.41	15.15	54 88	1103	A	1 080	5.05	63 51	4 92	66 50	53.54	86 43	6 87	6 70	72 86
						1104	B	1 079	4.75	60 18	7 79	64 40	47.64	82 76	6 53	10 71	65 52
						1110	A	....	7.35	58 09	10 57	56.86	40.17	76 42	9.67	13.91	62.84
12.60	8.25	73.27	11.79	14.95	46.53	1111	B	....	7.30	60 33	12 85	57.43	40 18	74.96	9.07	15.96	49.93
						1112	C	....	7.65	62 65	6.77	58.89	48.23	81 29	9 92	8.78	62.59
13 28	9 29	76.06	8.38	15.56	52.13	.....	...	....	3.697	54.47	7.73	55.95	42.33	81.88	7.56	10.58	63.81

TABLE B.—EXPERIMENTS

No. of analysis.	How defecated.	Neutral or alkaline.	Scum.	Character of precipitate.	Precipitate settled or not.	Juice after defecation.
708	$CaSO^3$		Little	Light; flocculent	Not settled without water	Light green.
761	$CaSO^3$		Heavy	Very light; flocculent.	Settled well	Yellowish green.
762	$CaSO^3$		do.	Light; flocculent		do.
763	Mixture	Strongly alkaline	do.	Heavy	Settled well	Dark wine color.
778	$CaSO^3$ + $Ca(OH)^2$.	Neutral	do.	do.	do.	Dark brown color.
779	$CaSO^3$+CaO	do.	do.	Light; flocculent	do.	do.
780	$CaSO^3$	do.	Little	do.	Settled	Yellowish green.
781	$CaSO^3$		Heavy	do.	Not settled	do.
782	$CaSO^3$		do.	do.	Not until neutralized.	do.
794	$CaSO^3$	Neutralized after defecation.	do.	do.	do.	Turbid; gray
795	$CaSO^3$	do.	do.	do.	do.	Grayish brown.
796	$CaSO^3$	do.	do.	Heavy; whitish green.	do.	Turbid; grayish brown.
810	Mixture	Slightly alkaline	do.	Heavy; light green.	Settled at once	Dark brown.
811	do.	Neutral	do.	do.	do.	Clear; light brown.
812	do.	Slightly alkaline	do.	Light green	do.	Clear; dark brown.
813	$CaSO^3$+ mixture.	do.	do.	Very light precipitate.	Settled well	Dark brown.
822	Mixture	do.	do.	Light; flocculent	do.	Clear; dark brown.
823	do.	do.	do.	do.		do.
824	do.	Neutral	do.	Very light; flocculent.	Settled well	Turbid; light brown.
837	do.	do.	do.	Light; flocculent	do.	Turbid; reddish brown
838	do.	Slightly alkaline	do.	Light; curdy	do.	Clear; light brown.
839	do.	Strongly alkaline	do.	Heavy; curdy; green.	do.	Clear; dark brown.
840	do.	do.	do.	do.	do.	
852	do.	*Strongly* alkaline	do.	Light; curdy	do.	Clear; dark brown.
853	do.	Slightly alkaline	do.	do.	do.	Clear; brown
854	do.	do.	do.	do.	do.	Clear; light brown.
855	do.	do.	do.	do.	do.	do.
867	do.	Neutral	do.	Light; flocculent	do.	Turbid; reddish brown
868	do.	Strongly alkaline	do.	Heavy; curdy	do.	Clear; light brown.
869	do.	do.	do.	do.	do.	do.
883	do.	Neutral	do.	Light; flocculent	do.	Turbid; light brown.
884	do.	Slightly alkaline	do.	Heavy; curdy	do.	Clear; dark brown.
885	do.	Strongly alkaline	do.	do.	do.	do.
896	do.	Slightly alkaline	do.	do.	do.	Clear; light brown.
897	do.	do.	do.	do.	do.	do.

IN DEFECATION.

Juice before syrup.	Character of syrup.	Character of sugar in December.	Remarks.	Scum while evaporating.
....	Light amber color.	....	....	Green.
....	Light brown color.	....	....	Little.
....	Light amber color.	....	White precipitate at 80°C; second defecated juice neutralized with $Ca.(OH)^2$.	None.
....	Dark color.	....	....	
....	Brown color.	....	Enough $Ca(OH)^2$ used to neutralize.	
....	Dark color.	....	....	
....	Turbid; yellow.	....	Defecated juice treated with $Ca(OH)^2$ gave heavy white precipitate.	None.
....	Clear; light brown.	....	Heavy white precipitate settled at once after neutralizing with $Ca(OH)^2$.	Do.
....	......do......	....	Heavy precipitate after adding $Ca(OH)^2$.	Do.
....	......do.....	....	......do............	White.
....	Light brown.	....	......do............	Scum.
....	Turbid; yellowish.	....	......do............	
Acid	Clear; light brown.	....	....	Scum.
Very acid......	......do......	....	....	
Acid	Slightly turbid; dark brown.	....	....	
......do.......	Light brown color.	....	....	
Slightly acid..	Clear; light amber.	Clear syrup; very few small crystals; long xx.	....	
......do.......	......do......	......do..	....	
Acid	Clear; light brown.	Slightly turbid; very few small crystals; long xx.	After skimming, neutralized with mixture.	
Strongly acid..	Turbid; light amber.	Slightly turbid..........	....	
......do.......	Clear; light amber.	Slightly turbid; thin.. ...	....	
Neutral........	Clear; dark amber.	Slightly turbid; about ½ heavy sediment.	....	
......do.......	......do.....	Three-fifths sediment; remainder clear.	....	
......do.......	Clear; dark yellow.	Heavy sediment; thin and clear.	....	
Slightly acid..	Clear; light amber.	Heavy sediment: turbid....	....	
......do.......	......do......	One-third sediment; clear; thin; light color	....	
......do.... ..	......do.. ...	Sediment turbid..........	....	
Strongly acid..	Bright, clear amber.	Cloudy; few large radiated xx.	....	Greenish yellow.
Neutral........	Clear; light amber.	......do.........	....	White, foamy.
......do.......	......do.. ...	Cloudy	....	Do.
Strongly acid..	Turbid; light amber.	Heavy sediment; turbid...	....	Yellowish green.
Slightly acid..	Clear; dark amber.	Heavy sediment; slightly turbid.	....	Do.
Neutral.	Clear; light amber	.....do..................	....	Do.
Slightly acid..	Clear; light brown.	Clear: slight sediment......	....	Green'h white
......do.......	Clear; dark color.	Clear; bright; few large radiated xx	Syrup scorched.........	Do.

TABLE B.—EXPERIMENTS

No. of analysis.	How defecated.	Neutral or alkaline.	Scum.	Character of precipitate.	Precipitate settled or not.	Juice after defecation.
898	Mixture	Slightly alkaline	Heavy	Heavy; curdy	Settled well	Clear; light brown.
899	do	do	do	do	do	do
911	do	Neutral	Heavy; curdy.	Light; flocculent	Not settled	Turbid; light brown.
912	do	Slightly alkaline	do	Heavy; curdy	Settled well	Clear; light brown.
913	do	Strongly alkaline	Very heavy	Very light; curdy.	do	Clear; dark reddish brown.
914	do	Alkaline	do	do	do	do
971	do	Slightly alkaline	Heavy	Slight; curdy	do	Clear; light reddish brown.
972	do	do	do	do	do	do
973	do	Strongly alkaline	Very heavy; curdy.	Very slight; curdy.	do	Clear; dark reddish brown.
984	do	Slightly alkaline	Thick; heavy	Slight; curdy	do	Clear; light reddish brown.
985	do	do	do	do	do	do
986	do	Strongly alkaline	do	Heavy; curdy	do	Dark reddish brown.
996	do	Slightly alkaline	do	Slight; curdy	do	Clear; light reddish brown.
997	do	Strongly alkaline	do	do	do	Clear; dark reddish brown.
998	do	do	do	do	do	do
1009	do	do	do	Light; flocculent	Not settled	Clear; light reddish brown.
1010	do	do	Heavy	do	do	do
1011	do	Slightly alkaline	Thick; heavy	Light; curdy	Settled well	do
1022	do	do	Very heavy	Slight; curdy	do	Clear; *light* brown.
1023	do	do	Heavy	Heavy; curdy	do	do
1024	do	do	Very heavy	do	do	do
1046	do	do	Heavy	Slight; curdy	do	Clear; light reddish brown.
1047	do	Strongly (?) alkaline.	Thick; heavy	Heavy; curdy	do	do
1048	do	Slightly alkaline	Heavy	Slight; curdy	do	do
1059	do	Neutral	do	do	do	Clear; light brown.
1060	do	Strongly alkaline	do	Very heavy; curdy.	do	do
1061	do	Slightly alkaline	do	Slight; curdy	do	do
1072	do	do	do	Heavy; curdy	do	Turbid; light brown.
1073	do	do	do	do	do	do

IN DEFECATION.—*Continued.*

Juice before syrup.	Character of syrup.	Character of sugar in December.	Remarks.	Scum while evaporating.
Slightly acid..	Clear: light brown.	Clear; sediment; *very* few crystals; long xx.	....	Green'h white
......do..	..... do.. ...	Nearly half sediment; remainder bright, clear.	Defecated juice stood 1½ hours before evaporation; became *dark* brown.	Do.
Strongly acid..	Clear; light amber.	One-half sediment; light; thin; clear.	....	White, foamy.
Slightly acid.	......do......	Half solid; very small yellowish xx; thin, clear syrup.	....	Clean, white, foamy.
Strongly alkaline.	Clear; dark brown.	Slightly turbid; thin; dark.	....	Thick, white.
Neutral.	Clear; light brown.	Two-thirds sediment; thin; dark.	Juice stood 1 hour before evaporating; became very dark clear brown.	White, foamy.
Slightly acid..	Clear; light amber.	Turbid; few medium xx. .	....	Do.
......do........	......do.. ...	Slightly turbid; few medium xx.	... .	Do.
Neutral........	......do......	Turbid; light; many medium large xx.	....	Do.
Slightly acid..	......do......	Turbid; light; thin.	....	Do.
......do........	......do.....	Thin; slightly turbid; light clear; many large xx.	....	Do.
Neutral........	.....do......	Thin; turbid; light color...	Juice became bright....	Clean, white, foamy.
Slightly acid..	......do......	Turbid; few medium xx...	....	White, foamy.
......do........	.....do......	Turbid; thin.....	Juice chang'd very light	Do.
......do..	......do.....	Sediment; turbid; very large xx.	......do......	Do.
Alkaline	Clear; dark brown.	One-third sediment; slightly cloudy.	Defecated juice became dark brown on standing 1 hour.	Do.
......do........	......do.. .	.... do............	.. do......	Do.
Slightly acid.	Clear: light amber.	Slightly turbid; small sediment.	N.B. Juice for 1009, 1010, and 1011 gave sour smell.	Do.
Acid	Clear; *light* amber.	Solid; yellowish; very small xx.	....	Clean, white foamy.
......do........	......do......	Very light; clear; semi-solid medium xx.	....	Do.
......do........	. ....do.. ..	Light clear; almost solid medium xx.	....	Do.
Slightly acid..	Very clear; light amber	*Solid;* small xx.	....	Do.
......do........	Clear; light amber.	Clear; bright; almost solid medium xx.	....	Do.
......do..... ..	......do.....	Clear; bright; ½ full large xx.	....	Do.
Acid	Clear; *light* amber.	Solid; clear; yellowish; small xx.	....	Do.
Slightly alkaline.	......do.. ...	Bright; clear; many large xx.	....	Do.
Slightly acid..	......do......	Very light; clear; semi-solid medium xx.	....	Do.
Acid	Turbid; light brown.	Slightly cloudy; ⅔ full medium small xx.	About half defecated juice lost in precipitate.	Yellowish green.
......do........	.... do.....	Slightly cloudy; ⅔ full *small* xx.	..... do..................	Do.

TABLE B.—EXPERIMENTS

No. of analysis.	How defecated.	Neutral or alkaline.	Scum.	Character of precipitate.	Precipitate settled or not.	Juice after defecation.
1074	Mixture	Strongly (?) alkaline.	Heavy	Heavy; curdy	Settled well	Slightly turbid; light brown.
1085	do	Slightly alkaline	do	Very heavy	do	Clear; light brown.
1086	do	Strongly alkaline	do	Very heavy; curdy.	do	do
1087	do	Strongly (?) alkaline.	do	do	do	do
1094	do	Strongly alkaline	do	*Very* heavy; curdy.	do	Clear; dark brown.
1095	do	Alkaline	do	do	do	do
1096	do	Neutral	Little	Heavy; curdy	do	Clear; light brown.
1103	do	Slightly alkaline	Heavy	*Very* heavy	do	do
1104	do	do	do	do	do	do
1110	do	Strongly alkaline	do	do	do	Dark red
1111	do	Slightly alkaline	do	do	do	do
1112	do	do	do	Very heavy	do	do

IN DEFECATION.—*Continued.*

Juice before syrup.	Character of syrup.	Character of sugar in December.	Remarks.	Scum while evaporating.
Slightly acid..	Turbid; light brown.	Clear; light color; large xx.	About half defecated juice lost in precipitate.	Yellowish green.
......do..	Clear; dark brown; scorched.	Clear; solid; medium xx..	......do............... ..	Green'h white
Slightly alkaline.	Turbid; light brown.	Clear; bright; semi-solid small xx.	......do..................	Do.
Slightly acid..	Clear; light brown.	Semi-solid; very small xx..	......do..................	Do.
Slightly alkaline.	Clear; light amber.	Solid; yellowish; very fine small xx.	. ....do........	White, foamy.
......do........	......do....	Clear; light; ½ full medium xx.	Part of defecated juice lost in precipitate.	Do.
Acid	......do......	Semi-solid; yellowish; *very* fine small xx.	....	Clean, white, foamy.
......do........	Clear; light brown.	Solid; small xx............	Part of juice lost in precipitate.	Do.
......do........	......do......	Clear; bright; almost solid small xx.	......do..................	Do.
Slightly alkaline.	Dark brown.	Clear; dark; nearly solid; small xx.	......do.................	Do.
Slightly acid..	Turbid; brown.	Solid; small xx; dark color.	.. ..do.................	Do.
Neutral........	Clear; dark brown.	......do......................	..... do........	Do.

TABLE C.—EXPERIMENTS IN DEFECATION.

No. of analysis.	Variety	Weight of juice.	Per cent of glucose.	Per cent of sucrose.	Per cent of solids not sugar.	Per cent of available sugar.	Glucose in juice.	Sucrose in juice.	Solids not sugar in juice.	Available sugar in juice.	No. of analysis.	Weight of syrup.	Per cent of glucose.	Per cent of sucrose.	Per cent of solids not sugar.	Per cent of available sugar.	Glucose in syrup recovered.	Sucrose in syrup recovered.	Solids not sugar in syrup.	Available sugar in syrup recovered.	Per cent of syrup in juice.	Character of syrup.
1071	New variety. R. Haswell	788	1.99	12.79	2.62	8.18	16	101	21	64	1072	144	7.35	57.71	7.38	42.98	11	83	11	61	18.3	*
		769					15	98	20	63	1073	158	7.15	56.00	7.37	41.48	11	88	12	65	20 3	XX solid.
		771					15	99	20	64	1074	164	6.95	57 43	3 62	46.86	11	94	6	77	21.3	XX few.
1084	Chinese Imphee. W. A. Sanders.	621	1.95	12.98	2.96	8.07	12	81	18	51	1085	129	6.75	55 53	7.00	41.78	9	72	9	54	20.8	XX solid.
		586					11	76	17	48	1086	138	6.70	54 63	8 87	39.06	9	75	12	54	23 6	XX solid.
		413					8	54	12	34	1087	94	6.90	54.15	9.75	37.50	6	51	9	36	22.8	XX solid.
1093	Undendebule. Natal	456	1.12	15.47	2 21	12.14	5	71	10	56	1094	101	4.05	62.46	4.01	54.40	4	63	4	55	22.1	XX solid.
		530					6	82	12	64	1095	118	3 80	60 71	5.93	50.98	4	72	7	61	22.3	XX ⅔
		614					7	95	14	74	1096	140	4 05	62 08	4 59	53 44	6	87	6	75	22.8	XX solid.
1102	Undendebule. Natal	501	1.33	13.90	2.72	9.85	5	70	14	51	1103	105	5.05	63 51	4.92	53.54	5	67	5	57	21.0	XX solid.
		500					7	70	14	49	1104	98	4 75	60 18	7 79	47 64	5	59	8	46	19.6	XX solid.
1109	Hlogonde, A—Natal	585	2.09	12.99	2 65	8.25	13	76	16	47	1110	125	7 35	58 09	10 57	40.17	9	73	13	51	21.4	XX ⅔
		760					16	99	20	63	1111	153	7.30	60 33	12 85	40.18	11	92	20	61	20.1	XX solid.
		612					13	79	16	50	1112	95	7.65	62.65	6.77	48.23	7	60	6	47	15.5	XX solid.
	Total	.....	...	....	...	......	149	1151	224	778	....	......	....	......	......	...	108	1,036	128	800	....	....

* NOTE.—XX=Crystallization.

Besides the experiments in defecation just recorded, and preliminary to them, the following experiments were made in the laboratory, with comparatively small quantities of juice, for the purpose of learning the effects of various defecating agents, especially lime, sulphurous acid, and sulphite of lime.

The results of these experiments are given in the following table, as being chiefly valuable to those who may desire to continue investigations in the same direction.

In each case a sample of juice was analyzed as usual, and then separate portions of this juice were submitted to different modes of treatment, and the resulting products were in each case fully examined, and the gain or loss of sucrose, glucose, and solids resulting from the several methods of defecation, were thus shown.

Number of juice.	Number of experiment.	Specific gravity.	Percentage of glucose.	Percentage of sucrose.	Percentage of solids not sugar.	Total solids.	In total solids. Percentage of glucose.	In total solids. Percentage of sucrose.	In total solids. Percentage of solids not sugar.	Remarks.
505	Juice	1.059	2.72	10.56	2.06	15.34	17.73	68.84	13.43	
527	1	1.061	2.47	9.78	3.11	15.36	16.08	63.67	21.15	20 hours cold + 10 grams per liter $CaSO^3$. Filtrate dark amber.
528	2	1.059	3.55	8.63	3.11	15.29	23.22	56.44	20.34	5 grams per liter $CaSO^3$, heated to 80° C. filtered. Next morning odor H^2S.
529	3	1.059	3.27	8.11	3.06	14.44	22.65	56.16	21.19	Passed SO^2 from 20 grams $CaSO^3$ into 1 L juice; bleached yellow, filtered.
530	4	1.059	3.54	8.07	3.68	15.29	23.15	52.78	24.07	Stood alone over night; soured; heavy precipitate. Filtrate light amber.
517	Juice	1.054	3.63	8.54	1.59	13.70	26.50	62.34	11.16?	
531	5	1.052	2.61	7.90	3.46	13.97	18.68	56.55	24.77	Heated to 77°C, and filtered. Filtrate light amber; good defecation.
532	6	1.053	2.75	7.98	3.23	13.96	19.70	57.16	23.14	Heated to boiling; better defecation than Experiment 5; filtrate lighter.
533	7	1.057	1.92	7.77	4.21	13.90	13.81	55.90	30.29	Added one per cent CaO; stood cold 30 minutes. Filtrate orange.
534	8	1.053	.59	9.81	3.03	13.43	4.39	73.05	22.56	Added one per cent CaO; heated nearly to 100°. Filtrate dark molasses color.
535	9	1.054	3.67	4.88	5.20	13.75	26.69	35.49	37.82	Used excess SO^2, heated to 82°C. Filtrate pale yellow. Good defecation.
536	10	1.052	2.60	7.67	3.32	13.59	19.13	56.44	24.43	4-5 L. juice, made moderately alkaline, 85° to 90°C., and filtered.
546	Juice	1.058	2.71	9.76	2.84	15.31	17.70	63.75	18.55	
547	11	1.041	4.74	4.06	2.53	11.33	41.84	35.92	12.24	Juice from Experiment 9 boiled to light colored syrup, to show *relative* results.
548	12	1.053	3.79	7.44	2.73	13.96	27.15	53.30	19.55	Lost, by broken flask.
549	13	1.053	3.23	8.43	2.30	13.96	23.14	60.39	16.47	Juice No. 546 simply filtered cold. Filtrate light amber.
550	14	1.051	3.15	8.04	2.36	13.55	23.25	59.34	17.41	Heated juice from Experiment 13 to 86°. Coagulation of albumen.
551	15	1.058	4.10	8.17	1.72	13.99	29.82	58.40	11.78	Filtered juice from Experiment No. 13 treated with SO^2, and allowed to stand 20 hours.
552	16	1.056	5.48	6.27	1.98	13.73	39.91	45.67	14.41	300 c. c. from Experiment 13 boiled to syrup, again diluted to 300 c. c. and analyzed.
563	Juice	1.054	4.05	7.41	3.72	15.18	26.68	48.81	24.51	
564	17	1.053	4.16	7.33	3.56	15.05	27.64	48.70	23.64	Juice No. 563 filtered cold.
565	18	1.051	3.93	7.84	2.55	14.32	27.44	54.75	17.81	Exactly neutralized with $Ca(OH)^2$ cold; filtered from white precipitate.
566	19	1.051	4.40	7.79	2.74	14.93	29.47	51.51	19.02	Filtered from experiment 18 boiled, and albumen filtered out.
567	20	1.048	4.17	6.95	2.33	13.45	31.00	51.67	17.33	Evaporated 200 c. c. to syrup; diluted to 200 c. c., filtered and analyzed.
588	Juice	1.053	3.92	7.12	3.91	14.95	26.22	47.62	26.16	
606	21	1.069	4.27	10.39	2.41	17.07	25.01	60.86	14.13	Juice 588 defecated by exactly neutralizing by $Ca(OH)^2$; filtered, evaporated to syrup, diluted, and analyzed.
605	22	1.057	4.55	8.49	1.52	14.66	31.03	57.91	11.06	Filtered juice from Experiment 21 analyzed August 9th. (Stood over night.)
608	23	1.049	3.87	7.87	.74	....	......	.	.....	Juice from Experiment 22, faintly alkaline by $Ca(OH)^2$, boiled to syrup, diluted and analyzed.
604	Juice	1.055	3.52	9.50	.91	13.93	25.27	68.19	6.54	
607	24	1.084	5.08	10.36	4.16	19.60	25.40	52.85	21.75	7 liters juice 604 + 35 grams CaO, defecated at 100°C. Evaporated to syrup, diluted, and analyzed.

CHAPTER X.

(*a.*) Concentration or evaporation of juice.
(*b.*) Methods of evaporation.
(*c.*) Vacuum pans.
(*d.*) Multiple effects.
(*e.*) Separation of sugar from molasses.
(*f.*) Sucrates of lime and strontia.

CONCENTRATION OR EVAPORATION OF JUICE.

Having, by filtering and defecation, separated as far as possible the impurities of the juice, the next step in the production of sugar is the removal of the excess of water, which is always present in saccharine juices.

By reference to the table on page 336, it will be seen that a solution of sugar, boiling at a temperature of 239° F. (115° C.), for example, will contain 85.2 per cent of sugar and 14.8 per cent of water, and if this solution is allowed to cool down to 60° F. (15.5° C.), the water present will hold in solution about twice its weight in sugar; *i. e.*, the 14.8 parts of water will dissolve 29.6 parts of sugar, and the remaining portion of sugar, 55.6 parts, will crystallize out from the solution. As the temperature is increased, the amount of water necessary to dissolve a given weight of sugar becomes less, as will be seen by consulting the table on page 336.

In slowly passing from a state of solution to that of a solid, those bodies, as sugar, salt, and others, which are able to assume a crystallizable form do so.

From the composition of the juice, it will be seen that about 84 per cent is water; *i. e.*, the sugar in the juice is in a solution of about five times its weight of water, and a large proportion must be removed in order to secure this sugar.

In order that this matter, which is fundamental, may be thoroughly understood, a few illustrations of the principles involved are given.

Common salt is soluble in about three times its weight of water. Suppose, now, that a pound of salt is dissolved in three pounds of water, and we evaporate rapidly one and a half pounds of water from the solution, it will be found that about half a pound of the salt will be thrown down as a solid, but in a fine powder. If, however, the water is slowly evaporated, we will have the salt crystallizing out in large cubical crystals.

Unlike the result with salt, which is but very little more soluble in hot than in cold water, when we evaporate a sugar solution in the open air, we find that the whole will remain in solution; and it is only when we allow the solution to cool, that we have the excess of sugar, which the water remaining is unable to hold in solution, crystallizing out.

The crystallization of sugar from its solution is a matter of the greatest simplicity. Many interested or ignorant persons have said, or thought, that there was some secret device by which the sugar could be secured; and many have represented that, by one thing or another, crystallization could be effected. The sugar may be obtained from a saccharine juice by any body, provided only the conditions for securing it are maintained; and these conditions are very few and very simple, and will be made plain in what follows.

It is also to be remembered, that no one is able to obtain sugar from a juice if it is not there; and yet there are many whose claims are such as to lead some to believe the contrary.

Crystallization is also a means of purification. To illustrate this point, suppose an ounce of common salt and an ounce of saltpeter (nitrate of potash) are together dissolved in a half pint of water, and the solution is allowed to evaporate slowly. It will be found that the crystals of salt and crystals of saltpeter will be separately formed as the water evaporates, and if the two are carefully picked out, each will be found to be entirely free from the other—that is, the salt crystallizes out by itself and the saltpeter by itself. Further, if to a solution of sugar there is added a solution of another substance, which does not crystallize, and evaporation takes place, the sugar will crystallize out, leaving the other substance in solution.

But it is found that the presence of certain substances will prevent the crystallization of sugar to a certain extent; also, the presence of certain others seems to favor or assist in the crystallization of sugar; while still other substances are apparently without any effect upon the sugar present. The saccharine juice of plants, even after the most careful defecation, is found to contain, besides the sugar, substances of each of the three classes. The most important one is glucose and inverted sugar, more or less of which is always present, and which is estimated by sugar boilers as being able to hold in solution its own weight of sugar. If, then, a pound each of glucose and sucrose should be dissolved in a quart of water and the solution evaporated, it would be found practically impossible to recover any of the sugar—but there would be obtained a little over two pounds of molasses. So, too, the salts or mineral matters present in the juice have each their specific

effect, either to retain more or less of the sugar present as molasses, or, as is the case with some, to cause the crystallization of more of the sugar than would have been obtained without them. Owing to this tendency of a substance when crystallizing to build up a crystal of pure material, it is found, generally, that the crystals of sugar, even when formed in a solution highly colored, are perfectly pure, and colorless as glass, and that the color of the ordinary yellow sugar is due almost entirely to the molasses which adheres to the surfaces of each minute crystal.

In the defecated juice there always remains a certain amount of impurities, which may be removed in the early stages of evaporation; and it will always be found that, as the evaporation progresses, a scum will form upon the surface, which may be easily removed by skimming. This scum will continue to rise, until the juice has been reduced to nearly one-half its bulk, or to a density of about 22° Beaumé, specific gravity 1.092.

A solution of sugar will, upon protracted boiling, suffer more or less inversion of the sugar: but it will be seen, from the experiments given upon page 297, that so long as there is an excess of lime in the solution, this inversion will not take place; also, that the effect of the heat, when lime is present, is the destruction of the glucose, with the formation of highly colored compounds, which will darken the syrup produced. In the production, then, of syrup, it is most desirable, in order to avoid a high color, that the removal of the water be effected as speedily as possible.

METHODS OF EVAPORATION.

The means by which the removal of the excess of water is accomplished are, in principle, the same, viz., the evaporation by heat; but the methods employed are numerous. They may be classed as,

1. Evaporation in open pans over the fire.
2. Evaporation in open pans by steam.
3. Evaporation from heated surfaces.
4. Evaporation from surfaces by hot air.
5. Evaporation in vacuum.

Evaporation in open Pans over the Fire.

This method is the most primitive and the most inexpensive. It is in use to a greater or less extent in every sugar producing country.

The following applications of this method will illustrate its extensive use.

The so-called Jamaica train consists, generally, of four large hemispherical copper boilers, mounted in brick work in a row, the fire being

built under one end and passing beneath each copper in succession to the chimney. This row of boilers is known as a "battery," and as the "copper wall." The several boilers are known as "the grande," it being the largest; "the flambeau," since it is just touched by the flames of the furnace; "the syrup," since in it the juice is concentrated to a syrup; and "the battery," or "strike," since from this the concentrated syrup is "struck" or dipped off into the coolers for crystallization.

The defecated juice is added to the largest pan nearest the chimney, and, as the juice becomes more and more concentrated, it is generally, by means of ladles, dipped from the one to the other until it reaches the last of the series, where it is evaporated to that degree of concentration which is found necessary. It is then ladled into coolers, and allowed to stand for crystallization, when the molasses is drained from the sugar, which is known in the trade as "muscovado."

In this process, a very large amount of sugar is lost through the high heat of the pans, which chars a portion of the sugar and darkens the product; but its simplicity and low cost is such, that, even at the present day, large quantities of sugar are thus produced. The same principle, although greatly perfected in details, is involved in a large number of evaporators in general use throughout the country for the production of syrup and sugar from sorghum. These need not be separately described, but the several points which constitute their improvements over the Jamaica Train of the creoles may be briefly mentioned:

1. The smaller quantity of juice under evaporation at any given time, thus proportionately diminishing the amount of inversion of sugar, and thus increasing the yield, owing to the rapidity with which the water is removed.

2. The protection of all portions of the evaporators not covered with juice or syrup from the direct contact with fire, and thus lessening the production of caramel and other products, which, besides destroying sugar, darken the syrup.

3. The introduction of devices for removing the scum during the concentration of the syrup, this greatly diminishing the labor of manufacture and the loss in sugar through this operation.

4. The arrangement of dampers beneath the several compartments of the pan, which in function correspond to the four boilers of the Jamaica Train, so that the heat may be moderated under each, or, as is necessary when the syrup after sufficient concentration is to be removed from the last pan, may be entirely shut off.

5. The very great reduction in cost in the apparatus necessary to the

manufacture of a commercial product, thus enabling one of even very limited means to provide himself with the apparatus necessary to work his crop.

Another simple and effective class of evaporators, are those which practically embody the advantages of the Jamaica Train, although consisting of but a single pan. The so-called "Cook Pan" well illustrates this class of evaporators. It is essentially an oblong pan of copper or iron, of a size varying from $3\frac{1}{2}$ feet $\times$ 6 to 5 feet $\times$ 30, which, by a series of partitions extending nearly across the pan, and separated from each other by spaces from 6 to 8 inches, cause the defecated juice, which is admitted at one end, to pass back and forth across the pan to the other end, so that, by adjusting the supply of juice, the evaporation is completed in the circuit, and the syrup is obtained in a continuous stream. By the interposition of gates, the pan is divided into several compartments, thus imitating in principle the Jamaica Train. The scum which rises during the earlier stages of the evaporation, is removed by skimming.

In theory, nothing would seem superior to this arrangement, and the results are exceedingly satisfactory. It will be seen at a glance that the juice is exposed to heat but a minimum of time, and there would appear to be little room for improvement, so long as direct heat is used. It is worthy of note, also, that, in pans of this character, the progress of the juice is the reverse of what it is in the Jamaica Train, the juice in the Cook Pan entering the end directly over the fire, and leaving at the end furthest away, thus diminishing the danger of burning the syrup.

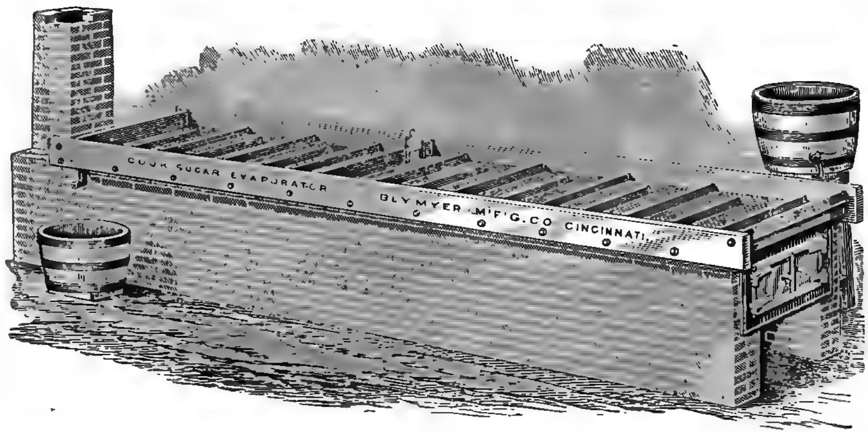


Plate XXXI.

COOK PAN FOR BRICK ARCH.

For stationary work on brick or stone arches, the pans are made with high ledges or divisions, with gates, as represented in the cuts herewith presented, and the flow is regulated by the gates. Nos. 1 and 2 have no high ledge or gate.

The above cut represents the Cook Pan for Brick Arch, Nos, 3, 4, and 5. They have one high ledge, with gate. This Cook Pan for Brick Arch, Nos. 6 and 7, has two high ledges, with gates. All sizes made, either of galvanized iron or copper. Full directions for building arch and working pan sent with each pan.

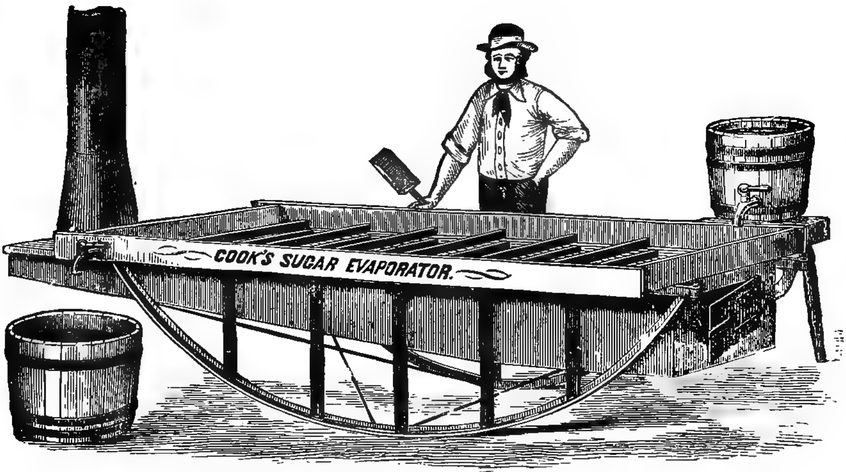


Plate XXXII.

PORTABLE EVAPORATOR—FURNACE AND PAN.

For the smaller pans, Nos. 2, 3, and 4, portable furnaces are provided. These are made of cast iron and sheet iron, heavily bound and riveted, strongly made, and the whole mounted upon rockers of angle iron—thus furnishing a complete portable furnace of iron and brick, combined in one, with all the advantages of both, and yet so light that it can be easily handled by two men. This is the most convenient arrangement for small home operations; and, for custom work, it is well nigh indispensable. With it the operator can move from field to field, or from farm to farm, and thus avoid the labor and expense of hauling the cane.

Plate XXXIII.

AUTOMATIC COOK PAN.

The *Automatic Cook Pan* has three divisions, each performing separate offices, and all connected by high ledges and gates, under the full control of the operator. The processes of defecation, clarification, and finishing, are systematically carried on without interruption to the end.

The *first division* frees the juice from its crude impurities, whilst passing through the channels, by the automatic action of the skimming device, which throws the scum in an opposite direction from the moving juice.

In the *second division*, the juice is freed from its remaining impurities and reduced to semi-syrup. This division is provided with high ledges, to prevent the mixing of the juice; and is so constructed, that the scum is thrown to the opposite side, or into the trough, to be returned to the first division for *re-separation.* This saves *a considerable percentage of syrup.*

The semi-syrup is taken by the *third division,* and finished as rapidly as possible to the sugar point, and drawn into coolers.

The Automatic Cook Pan *secures thorough defecation,* saves *a large percentage of juice* that would otherwise be wasted, and *saves labor in skimming and fuel.*

Full direction for building arch and working pan sent with each pan.

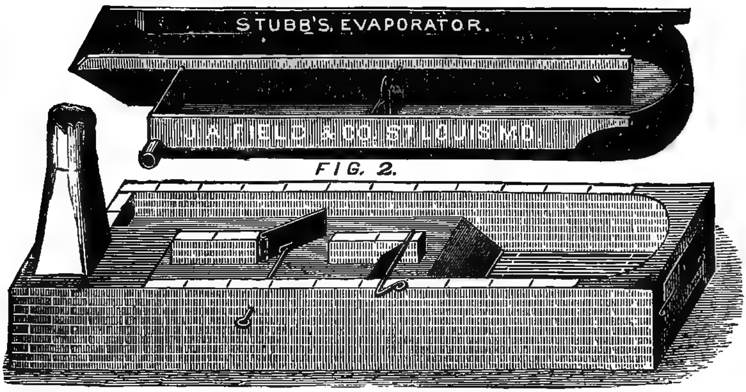


Plate XXXIV.

THE STUBBS EVAPORATOR.

Plate XXXIV represents the Stubbs Evaporator. The upper cut shows the pan with two compartments. The first occupies three-fourths of the pan; the second compartment the remaining fourth. The juice enters the first compartment near the smoke-stack in a regular stream, passing around the circle over the fire-box to cross-partitions, where it thickens to a semi-syrup. Being over the hottest part of the furnace, it raises to a light foam, which breaks to the lowest point where the cool juice enters, not only keeping back the green scum, but carrying all the scum off of thirty feet surface, where it is scraped off without loss of sweet. The semi-syrup is turned into the second compartment at intervals, to be finished under full control of heat governed by dampers. When done, to be run off with scraper, letting semi-syrup follow. Boil rapidly with two inches juice in order to cleanse well.

The lower engraving represents the furnace. Should be built of brick, with eight-inch wall fourteen inches above fire-grate; the balance seven inches. A sectional arch with one damper in center, hinged at the back end to swing to back wall; also damper across the mouth of left flue. The smoke-stack stands back, as the cut indicates. The smoke-stack should be sixteen feet high, fourteen inches diameter.

The following table has been prepared to enable the reader readily to convert the degrees of the Centigrade thermometer into degrees upon the Fahrenheit scale, although it has been the aim to give both, whenever temperature has been mentioned in the text.

TABLE FOR CONVERSION OF CENTIGRADE DEGREES INTO FAHRENHEIT DEGREES.

Centigrade.	Fahrenheit.	Centigrade.	Fahrenheit.	Centigrade.	Fahrenheit.	Centigrade.	Fahrenheit.	Centigrade.	Fahrenheit.	Centigrade.	Fahrenheit.	Centigrade.	Fahrenheit.	Centigrade.	Fahrenheit.
°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
-37	-34.6	-13	8.6	11	51.8	35	95.0	59	138.2	83	181.4	107	224.6	130	266.0
-36	-32.8	-12	10.4	12	53.6	36	96.8	60	140.0	84	183.2	108	226.4	131	267.8
-35	-31.0	-11	12.2	13	55.4	37	98.6	61	141.8	85	185.0	109	228.2	132	269.6
-34	-29.2	-10	14.0	14	57.2	38	100.4	62	143.6	86	186.8	110	230.0	133	271.4
-33	-27.4	- 9	15.8	15	59.0	39	102.2	63	145.4	87	188.6	111	231.8	134	273.2
-32	-25.6	- 8	17.6	16	60.8	40	104.0	64	147.2	88	190.4	112	233.6	135	275.0
-31	-23.8	- 7	19.4	17	62.6	41	105.8	65	149.0	89	192.2	113	235.4	136	276.8
-30	-22 0	- 6	21.2	18	64.4	42	107.6	66	150.8	90	194.0	114	237.2	137	278.6
-29	-20.2	- 5	23.0	19	66.2	43	109.4	67	152.6	91	195.8	115	239.0	138	280.4
-28	-18.4	- 4	24.8	20	68.0	44	111.2	68	154.4	92	197.6	116	240.8	139	282 2
-27	-16.6	- 3	26.6	21	69.8	45	113.0	69	156.2	93	199.4	117	242.6	140	284.0
-26	-14.8	- 2	28.4	22	71.6	46	114.8	70	158.0	94	201.2	118	244.4	141	285.8
-25	-13.0	- 1	30.2	23	73.4	47	116.6	71	159.8	95	203.0	119	246.2	142	287.6
-24	-11.2	0	32 0	24	75.2	48	118.4	72	161.6	96	204.8	120	248.0	143	289.4
-23	- 9.4	+ 1	33.8	25	77.0	49	120.2	73	163.4	97	206.6	121	249.8	144	291.2
-22	- 7.6	2	35.6	26	78.8	50	122.0	74	165.2	98	208.4	122	251.6	145	293.0
-21	- 5.8	3	37.4	27	80.6	51	123.8	75	167.0	99	210.2	123	253.4	146	294.8
-20	- 4 0	4	39.2	28	82.4	52	125.6	76	168.8	100	212.0	124	255.2	147	296.6
-19	- 2.2	5	41.0	29	84.2	53	127.4	77	170.6	101	213.8	125	257.0	148	298.4
-18	- 0.4	6	42.8	30	86.0	54	129.2	78	172.4	102	215.6	126	258.8	149	300.2
-17	+ 1.4	7	44.6	31	87.8	55	131.0	79	174.2	103	217.4	127	260.6	150	302.0
-16	3.2	8	46.4	32	89 6	56	132.8	80	176.0	104	219.2	128	262.4	151	303.8
-15	5.0	9	48.2	33	91.4	57	134.6	81	177 8	105	221.0	129	264.2	152	305.6
-14	6.8	10	50.0	34	93.2	58	136.4	82	179.6	106	222.8				

By means of the following table, the manufacturer may be able to determine the percentage of total solids in his juice or syrup, by simply taking the specific gravity at any temperature not over 100° C. or 212° F. For example, a sample of syrup, at a temperature of 80° C., had a specific gravity of 1.2862—that syrup contains 65 per cent of total solids; and at 15° C. this sample would have a density of 1.3211. For temperatures and percentages between those tabulated, it will be easy to make the necessary calculations.

SPECIFIC GRAVITY OF SUGAR SOLUTIONS AT DIFFERENT TEMPERATURES AND CONCENTRATIONS (AFTER GERLACH).

Temp. C°	Temp. F°	0 per cent.	5 per cent.	10 per cent.	15 per cent.	20 per cent.	25 per cent.	30 per cent.	35 per cent.	40 per cent.	45 per cent.	50 per cent.	55 per cent.	60 per cent.	65 per cent.	70 per cent.	75 per cent.
0	32	1.0007	1.0210	1.0418	1.0636	1.0861	1.1094	1.1337	1.1586	1.1845	1.2113	1.2390	1.2676	1.2972	1.3276	1.3590	1.3916
5	41	1.0009	1.0210	1.0417	1.0632	1.0856	1.1089	1.1329	1.1577	1.1833	1.2098	1.2372	1.2657	1.2951	1.3255	1.3568	1.3892
10	50	1.0008	1.0208	1.0413	1.0627	1.0849	1.1079	1.1318	1.1565	1.1819	1.2082	1.2355	1.2638	1.2931	1.3233	1.3545	1.3869
15	59	1.0003	1.0202	1.0406	1.0619	1.0839	1.1067	1.1305	1.1550	1.1802	1.2065	1.2337	1.2619	1.2910	1.3211	1.3522	1.3845
17.5	63.5	1.0000	1.0197	1.0401	1.0613	1.0832	1.1060	1.1296	1.1540	1.1794	1.2056	1.2327	1.2609	1.2900	1.3200	1.3512	1.3833
20	68	.9996	1.0191	1.0395	1.0606	1.0825	1.1052	1.1288	1.1532	1.1785	1.2046	1.2317	1.2599	1.2889	1.3189	1.3500	1.3822
25	77	.9686	1.0179	1.0382	1.0592	1.0810	1.1036	1.1271	1.1514	1.1766	1.2026	1.2296	1.2578	1.2867	1.3166	1.3477	1.3798
30	86	.9973	1.0166	1.0367	1.0576	1.0795	1.1018	1.1253	1.1495	1.1746	1.2005	1.2274	1.2555	1.2844	1.3142	1.3454	1.3773
35	95	.9958	1.0150	1.0351	1.0560	1.0775	1.1000	1.1233	1.1474	1.1726	1.1982	1.2251	1.2531	1.2820	1.3117	1.3430	1.3748
40	104	.9942	1.0133	1.0332	1.0540	1.0756	1.0978	1.1212	1.1452	1.1701	1.1958	1.2227	1.2507	1.2794	1.3091	1.3405	1.3722
45	113	.9923	1.0113	1.0311	1.0519	1.0733	1.0956	1.1188	1.1428	1.1677	1.1933	1.2202	1.2481	1.2768	1.3065	1.3380	1.3695
50	122	.9903	1.0092	1.0290	1.0496	1.0710	1.0932	1.1164	1.1403	1.1651	1.1907	1.2175	1.2454	1.2741	1.3038	1.3352	1.3667
55	131	.9881	1.0069	1.0266	1.0472	1.0685	1.0907	1.1138	1.1378	1.1624	1.1879	1.2148	1.2426	1.2712	1.3010	1.3325	1.3639
60	140	.9857	1.0044	1.0242	1.0448	1.0660	1.0881	1.1114	1.1351	1.1594	1.1851	1.2119	1.2397	1.2683	1.2982	1.3295	1.3610
65	149	.9831	1.0018	1.0217	1.0421	1.0634	1.0854	1.1084	1.1324	1.1567	1.1822	1.2091	1.2367	1.2654	1.2953	1.3265	1.3580
70	158	.9804	.9992	1.0190	1.0393	1.0607	1.0827	1.1056	1.1295	1.1538	1.1792	1.2062	1.2337	1.2624	1.2923	1.3233	1.3552
75	167	.9775	.9964	1.0162	1.0363	1.0578	1.0798	1.1027	1.1265	1.1509	1.1761	1.2031	1.2307	1.2593	1.2893	1.3201	1.3520
80	176	.9745	.9935	1.0132	1.0336	1.0547	1.0768	1.0997	1.1234	1.1479	1.1729	1.2000	1.2276	1.2562	1.2862	1.3168	1.3488
85	185	.9714	.9905	1.0101	1.0305	1.0515	1.0736	1.0965	1.1202	1.1448	1.1696	1.1967	1.2246	1.2529	1.2829	1.3136	1.3456
90	194	.9683	.9872	1.0068	1.0272	1.0481	1.0701	1.0931	1.1169	1.1415	1.1664	1.1934	1.2213	1.2496	1.2796	1.3103	1.3423
95	203	.9652	.9838	1.0034	1.0237	1.0447	1.0668	1.0897	1.1135	1.1381	1.1630	1.1899	1.2179	1.2462	1.2763	1.3067	1.3390
100	212	.9621	.9804	.9999	1.0202	1.0413	1.0634	1.0863	1.1099	1.1346	1.1597	1.1864	1.2145	1.2427	1.2728	1.3032	1.3356

The following table gives the temperatures at which solutions of sugar of different degrees of concentration boil, the percentage of sugar present in each case, the degrees Beaumé and density of each at the temperature of boiling, and also at the ordinary temperature of 15° C. or 59° F.

For example, a solution containing 79.5 per cent of sugar will boil at 110° C. or 230° F., and at this temperature will have a density of 38°.5 Beaumé, or specific gravity of 1.364; and when cooled to 15° C. or 59° F. will have a density of 42°.8 Beaumé, and a specific gravity of 1.4215.

TABLE OF BOILING POINT, DEGREES BEAUMÉ, SPECIFIC GRAVITY, AND PER CENT OF SUGAR OF SACCHARINE SOLUTIONS.

Boiling Point.		Per cent of sugar.	Beaumé.		(Flourens) Specific gravity.	
Temp. C. °	Temp. F. °		at temp. of observation.	at 15° C.	at temp. of observation.	at 15° C.
104.5	220.1	67.2	32.20	36 25	1.2872	1.3350
105.	221.0	69.1	33.20	37.25	1.2990	1.3480
105.5	221.9	71.2	34.20	38.30	1.3106	1·3613
106.	222.8	72.4	35.00	39.10	1.3200	1.3720
106.5	223.7	73 4	35.50	39.65	1 3260	1.3780
107.	224.6	74.4	36.00	40.15	1.3325	1.3855
107.5	225.5	75.2	36.50	40.70	1.3385	1.3925
108.	226.4	76.4	37.00	41.10	1.3450	1.3985
108.5	227.3	77.4	37.50	41.75	1.3510	1.4080
109.	228.2	77.8	37.90	42.10	1.3562	1 4120
109.5	229 1	78.7	38 25	42.50	1.3606	1 4180
110.	230.0	79 5	38.50	42.80	1.3640	1.4215
110.5	230.9	80 0	38.75	43 00	1.3670	1.4245
111.	231 8	80 6	39.00	43.30	1.3700	1 4290
111 5	232.7	81.4	39.30	43.65	1.3740	1 4335
112.	233.6	82.2	39.60	44.00	1.3770	1.4380
112.5	234.5	82.9	39.80	44.20	1·3810	1.4415
113.	235.4	83 6	40.00	44.40	1.3835	1.4500
114.	237.2	84.2	40.30	....	1.3875	....
115.	239.0	85.2	40.60	....	1.3915	....
116.	240.8	85.8	40.90	....	1 3955	....
117.	242.6	86.5	41.20	....	1.4000	....
118.	244.4	87.2	41.45	....	1.4030	....
119.	246 2	87.9	41.65	....	1.4060	....
120.	248 0	88.5	41 90	....	1.4085	....
125.	257.0	91.2	42 80	....	1.4215	....
130.	266.0	92.2	43.50	....	1.4315	....

The following table, calculated by Mategczeh, Scheibler, and Stammer, shows the comparison of degrees Beaumé with specific gravity, as also with the scale of Brix, which represents the percentage of total solids present in the solution. It also gives the number of pounds avoirdupois which an American gallon of the solution of each density would weigh. For example, a juice of 10° Beaumé would have a specific gravity of 1.0744, would contain 18 per cent of solids, and would weigh 8.96 pounds to the gallon; or a syrup of 43° Beaumé

would have a specific gravity of 1.4267, would contain 81.5 per cent of solid matters, and would weigh 11.9 pounds to the gallon:

Degrees Beaumé.	Specific gravity.	Degrees Brix, or per cent total solids.	Pounds per gallon.	Degrees Beaumé.	Specific gravity.	Degrees Brix, or per cent total solids.	Pounds per gallon.
.5	1.0035	[illegible]	8.37	26.5	1.2256	48.7	10.22
1.	1.0070	1.8	8.40	27.	1.2306	49.6	10.26
1.5	1.0105	2.7	8.43	27.5	1.2361	50.6	10.31
2.	1.0141	3.6	8.46	28.	1.2411	51.5	10.35
2.5	1.0177	4.5	8.49	28.5	1.2467	52.5	10.39
3.	1.0217	5.5	8.52	29	1.2523	53.5	10.44
3.5	1.0249	6.3	8.55	29.5	1.2574	54.4	10.48
4.	1.0286	7.2	8.58	30.	1.2631	55.4	10.53
4.5	1.0323	8.1	8.61	30.5	1.2689	56.4	10.57
5.	1.0360	9.0	8.64	31.	1.2741	57.3	10.62
5.5	1.0397	9.9	8.67	31.5	1.2799	58.3	10.67
6.	1.0435	10.8	8.70	32	1.2859	59.3	10.72
6.5	1.0472	11.7	8.73	32.5	1.2911	60.3	10.77
7.	1.0510	12.6	8.76	33.	1.2970	61.2	10.82
7.5	1.0549	13.5	8.80	33.5	1.3030	62.2	10.87
8.	1.0587	14.4	8.83	34.	1.3084	63.1	10.92
8.5	1.0630	15.4	8.86	34.5	1.3154	64.1	10.96
9.	1.0670	16.8	8.89	35.	1.3211	65.2	11.02
9.5	1.0704	17.1	8.92	35.5	1.3272	66.2	11.07
10.	1.0744	18.0	8.96	36.	1.3333	67.2	11.12
10.5	1.0784	18.9	8.99	36.5	1.3395	68.2	11.17
11.	1.0829	19.9	9.02	37.	1.3458	69.2	11.22
11.5	1.0869	20.8	9.06	37.5	1.3521	70.2	11.27
12	1.0909	21.7	9.10	38.	1.3585	71.2	11.33
12.5	1.0950	22.6	9.13	38.5	1.3649	72.2	11.38
13.	1.0991	23.5	9.16	39.	1.3714	73.2	11.44
13.5	1.1033	24.4	9.20	39.5	1.3780	74.2	11.49
14.	1.1074	25.3	9.23	40.	1.3846	75.3	11.55
14.5	1.1116	26.2	9.27	40.5	1.3913	76.3	11.60
15.	1.1163	27.2	9.31	41.	1.3981	77.3	11.66
15.5	1.1206	28.1	9.34	41.5	1.4049	78.3	11.72
16.	1.1249	29.0	9.38	42.	1.4118	79.4	11.77
16.5	1.1292	29.9	9.41	42.5	1.4187	80.4	11.83
17	1.1335	30.8	9.45	43.	1.4267	81.5	11.90
17.5	1.1384	31.8	9.49	43.5	1.4328	82.5	11.95
18.	1.1427	32.7	9.53	44.	1.4400	83.6	12.01
18.5	1.1472	33.6	9.56	44.5	1.4472	84.6	12.07
19.	1.1521	34.6	9.61	45	1.4545	85.7	12.13
19.5	1.1566	35.5	9.64	45.5	1.4619	86.7	12.19
20.	1.1611	36.4	9.68	46.	1.4694	87.8	12.26
20.5	1.1662	37.4	9.72	46.5	1.4769	88.8	12.32
21.	1.1707	38.3	9.76	47.	1.4845	90.0	12.38
21.5	1.1753	39.2	9.80	47.5	1.4922	91.0	12.45
22.	1.1799	40.1	9.84	48.	1.5000	92.1	12.51
22.5	1.1851	41.1	9.88	48.5	1.5079	93.2	12.57
23.	1.1903	42.1	9.92	49.	1.5158	94.3	12.64
23.5	1.1950	43.0	9.96	49.5	1.5238	95.4	12.71
24	1.2003	44.0	10.01	50.	1.5319	96.5	12.78
24.5	1.2051	44.9	10.05	50.5	1.5401	97.6	12.84
25.	1.2104	45.9	10.09	51.	1.5484	98.7	12.91
25.5	1.2153	46.8	10.13	51.5	1.5568	100.0	12.98
26.	1.2202	47.7	10.17	.....	....	....	....

Evaporation in Open Pans and by Steam.

Owing to the far greater ease with which the heat may be applied and regulated, it is extensively employed, both in the operations of defecation and evaporation. In open pans it is applied by means of a coil of iron (or, preferably, copper) pipe, as in the defecator; and since the heat may thus be applied over a greatly increased surface, and at any temperature and pressure, the evaporation is proportionately more rapid than from a pan which is heated directly over the fire. The relative evaporating capacity of pans heated by direct heat and by steam, may be learned by the following comparisons. The average evaporation from an open pan over a fire, the grate surface of which is about one-fourth to one-third the size of the pan, is about one gallon of water to each square foot of surface in the pan per hour. Pans of large size evaporate a larger amount proportionately than small ones, and with greater economy of fuel, and less relative waste. To illustrate: pans of the following dimensions are claimed to evaporate as follows:

Size.	Feet of surface.	Gallons per hour. per foot surface.
40 × 120 inches	33⅓	4
40 × 192 inches	53⅓	.7
40 × 288 inches	80	1.3
44 × 108 inches	35	.8
44 × 144 inches	44	1 1
44 × 180 inches	55	1 1

Experiments were made at the Department of Agriculture, by the author, with two evaporators heated by copper coils with steam at the pressure of 55 pounds.

As an average of seven experiments, with two evaporators, it was found that there were evaporated four gallons of water per hour from each square foot of surface of the juice in the evaporator. One evaporator was seven feet in diameter; the other, four feet ten inches. Both were circular.

Practically, the same results are reported by others in their work with similar evaporators.

The importance of keeping up a brisk boiling, must not be forgotten; for it has been found that the transmission of heat from steam pipes is two and a half times as rapid when the water is boiling vigorously, as when it is at rest as in the heating up of the juice in the act of defecation. This great difference is obviously due to the rapid circulation and distribution of the heat when the boiling is going on, as compared with the very slow movements in the mass of water when not boiling.

It is found, also, that the heat given out by steam coils to boiling juice, is about fifteen per cent less than that given out to boiling water,

and this result is obviously due to the comparatively sluggish juice, as compared with the water.

Surface or Film Evaporation.

A very large number of evaporators have been devised (some of which appear to have given excellent results in practice), based upon the evaporation of the water from thin films of juice distributed over heated surfaces, or exposed to hot and dry air. Among the many forms of apraratus constructed upon this principle, may be mentioned the following:

1. A continuous sheet of cloth, passing over two sets of rollers, at the top and bottom of a chamber through which, by means of a fan, fresh hot and dry air is made to pass. The lower rolls are placed beneath the surface of the juice to be evaporated, so that, by the revolution of the cloth, a fresh portion of the juice is constantly exposed to the hot air.

2. A long, hollow cylinder, heated by the waste steam of the sugar house, which passes through it, and which, revolving in the juice, in which it is partly immersed, presents a fresh film constantly to the air.

3. The substitution of hollow discs upon a common axle, the hollow axle permitting the steam to enter and heat the discs, which are caused to revolve partially immersed in the juice to be evaporated.

4. A spiral hollow coil, through which steam passes, which also revolves partially in the juice.

5. An upright hollow cylinder (15 or 20 inches in diameter, 10 to 12 feet long), heated within by steam, over which, from the upper end, the juice is allowed to stream, the distribution of the juice over the surface of the cylinder being effected by circular troughs about the cylinder, at intervals, which, by their overflow, secure the distribution of the juice in a film, which otherwise would form streams from the top to the bottom of the cylinder.

6. Still another form is a skeleton cylinder, consisting of two steam tight circular drums, which are connected together by a series of tubes which enter the periphery of each drum, and through which the steam passes from one drum to the other. This cylinder revolves horizontally, with its lower portion dipping in the juice, and thus presents a large surface for evaporation.

None of these surface evaporators permit the removal of any impurities by skimming; and they can not, therefore, be used except for the concentration of semi-syrup of 22° to 25° Beaumé, since the juice requires more or less skimming during its evaporation, until it has reached that density.

It would appear, however, that this principle possesses some valuable features, especially if so contrived as to complete the evaporation of a given quantity of juice at once; for it is found that the evaporation from a thin film is rapid, even at temperatures far below the boiling point, as is known to everybody in the familiar process of drying clothes by hanging them upon a line. The principal objection urged against all evaporators of this class, does not appear, as yet, to have been overcome in practice, viz.: the drying and adhering to the heated surfaces of a gradually increasing crust of sugar, which not only prevents, to a great extent, evaporation, by being a poor conductor of heat, but results in the inversion of a large portion of the sugar which is thus adhering.

Pan Scale.

In the process of evaporation, especially with the open pan, considerable trouble arises from the formation of a white scale upon the pan, which not only retards evaporation, but becomes, when loosened, incorporated with the syrup. An analysis of this scale, shows it to be composed, when deposited from sorghum juice, of a lime salt of aconitic acid. This acid has been detected in the molasses of sugar-cane, and it is probable that a similar deposit found upon the evaporators of sugar-cane juice, and generally called lime, is of like composition. The average of three analyses of scale, from a concretor used for the juice of sugar-cane, gave the following composition:

ANALYSIS OF PAN SCALE.

	Per cent.
Moisture	5 36
Organic	18.05
Insoluble	14 24
Sulphuric acid	.96
Phosphoric acid	8 43
Lime	37 98
Iron	2.61
Alkalis, etc	12.37
	100.00

The character of the organic matter in the above is not given, but it is by no means improbable that this scale is in part composed of the same salt. The practical question concerning it, is its removal from the pans, since, by its poor conducting power, it will cause the pans to be heated even red hot, thus burning them out; and besides, if, cracking loose, it admits the syrup to this red hot pan, burning is inevitable.

The use of diluted acids, sulphuric, hydrochloric, or even vinegar, has been recommended for its removal; but, if used, the pan must not long be in contact with these stronger acids, and, after their use, the

pan must be repeatedly washed and rinsed with water, to remove every portion of the acid.

A method which has been found effective with the open pan, has been to wipe the pan quite dry, and before using it to burn a small armful of straw or shavings under the pan, the sudden expansion of the iron by the momentary blaze cracking the scale loose, so that it may be swept out of the pan with a broom. Of course, care must be taken to avoid unsoldering of the pan in this operation, of which there is no danger if the blaze is only of short duration. It is very interesting to observe, that a similar scale is often found in the pans when maple sap is evaporated; but this scale has been found to be the lime salt of malic, another organic acid.

VACUUM PANS.

The principle upon which the vacuum pan is based, is the fact that the boiling point of water, syrup, or any liquid, is in part, dependent upon the pressure of the atmosphere, and that the temperature at which a liquid boils, is higher or lower, according as the atmospheric pressure is increased or diminished. For example, the boiling point of water at the sea level, is 212° F. (100° C.), and the pressure of the atmosphere is equal to the pressure of a column of mercury 30 inches (776 mm.) high; but it is found that, at the summit of Mount Blanc, which is 15,560 feet above the level of the sea, water boils at 185°.8 F. (85°.6 C), and that the pressure of the atmosphere at the summit, is only equal to a column of mercury 17,363 inches high (449 mm.)

It appears, then, an elevation of about 600 feet diminishes the boiling point 1°F., and this is demonstrated as due to the fact, that the pressure of the atmosphere is diminished by leaving a portion of the atmosphere below us in the ascent. Conversely, if we descend a mine, we find the boiling point increases, owing to increase of pressure, as indicated by the barometer.

If, now, by artificial means, the pressure of the atmosphere is in part or wholly removed from a liquid, we find the boiling point is proportionably diminished; and in fact, the boiling point of water has been reduced in a vacuum approximately perfect to 70°F. (21°.1C).

The vacuum pan, which was invented by Howard in 1813, and which has come into such general use in the evaporation of liquids, works by the principle above illustrated. Its importance in sugar making is due to the fact, that, by the avoidance of high temperatures, there is no danger of burning the sugar, as is frequent with open pans; and the inversion of the sugar is reduced to a minimum.

Also, the rapidity of the operation is greatly increased, since the evaporation in a vacuum proceeds very rapidly.

The amount of vacuum in the pan is stated in inches, in the sugar house, and is determined by a barometer connected with the interior of the pan. Thus, 28 inches of vacuum means, that the pressure within the pan is equal to only 2 inches of mercury at the sea level; 20 inches vacuum means, that two-thirds of the pressure has been removed from within the pan.

It is obvious, that the pressure on the pan by the surrounding atmosphere, when any thing approaching a good vacuum is attained, becomes enormous; 28 inches vacuum is common with good pans, and a pan 8 feet in diameter would then sustain an outside pressure of at least 200 tons. The pan, therefore, must be constructed of material able to sustain this pressure.

The following table gives the boiling points for syrup in the vacuum pan, for the several degrees of vacuum which are obtained in practice. It is taken from Ures' Dictionary of Arts and Manufactures:

BOILING POINTS IN VACUUM PAN.

Inches of vacuum.	Temperature, Fahrenheit.	Temperature, Centigrade.
26.00	175°	79°.4
26.38	170°	76°.7
26.90	165°	73°.9
27.28	160°	71°.1
27.64	155°	68°.4
27.95	150°	65°.6
28.20	145°	62°.8
28.43	140°	60°.0
28.64	135°	57°.2
28 83	130°	54°.4
28.99	125°	51°.7
29.14	120°	48°.9
29.26	115°	46°.1

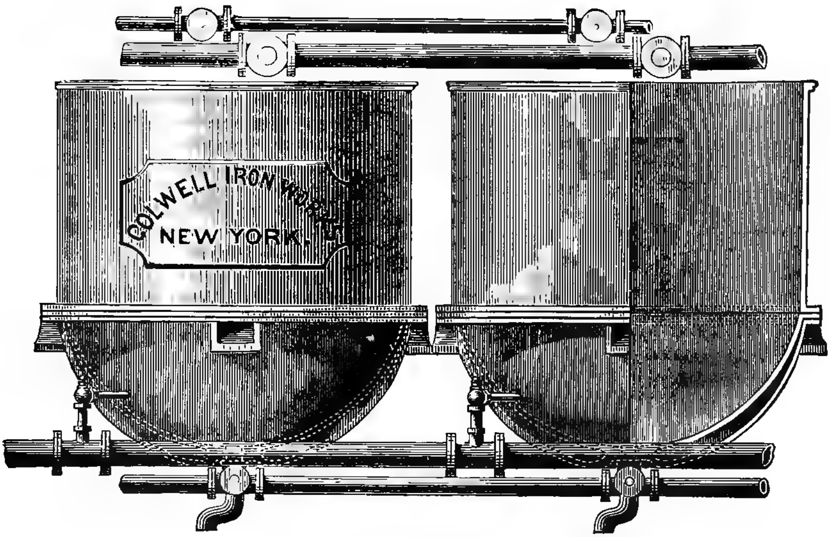
In construction, the vacuum pan consists of a spherical or oval vessel of copper or iron, from four to ten or more feet in diameter, provided with one or more coils of copper tubes, to either or all of which steam may be admitted by means of cocks. These coils occupy about one-fourth or one-third the height of the pan. From the top of the pan a large pipe proceeds, which enters first a receptacle, called the overflow, which is to catch and retain any portion of the contents of the pan which may by accident boil over. From the bottom of this receptacle a tube, provided with a stop-cock, passes back to the vacuum pan, in order that such overflow may be returned at intervals.

The large tube proceeding from the vacuum pan is connected with the condenser, where the vapor escaping from the pan is condensed,

and removed by the vacuum pump. Condensation is effected by a jet of water, similar to the method of condensing engines, or, when water is limited, surface condensation is made use of: the vapor passing through a system of pipes, over which water is allowed to trickle. In the one case, the water used in condensation, as also the condensed vapor, is removed by a steam pump; in the latter, only the condensed vapor, and such uncondensed portion as remains, is removed by the pump. At the bottom of the vacuum pan a sliding valve permits the discharge of the contents, when concentration is completed. The semi-syrup is forced into the pan through a pipe connected with the syrup tank, by atmospheric pressure, owing to the vacuum in the pan. A barometer and thermometer are connected with the interior of the pan, by which the extent of the vacuum and the temperature of the contents are indicated at a glance; also a proof stick, which enables a portion of the contents of the pan to be removed for examination without breaking the vacuum. Eye-glasses in the sides of the pan enable the sugar-boiler to watch and thus control the operations.

The volume which a gas occupies being inversely as the pressure, it follows that, with a vacuum of 28 inches, a cubic foot of water ($7\frac{1}{2}$ gallons), which would produce, at the ordinary pressure of the atmosphere, 1700 cubic feet of steam, would yield, at 28 inches of vacuum, 25,500 cubic feet. It is found that a cubic foot of water will produce 21,500 cubic feet of steam under a pressure of 2 inches of mercury.

The pipe which is to discharge from the pan the enormous bulk of rarified steam generated, must be adequate, as also the apparatus for condensation.



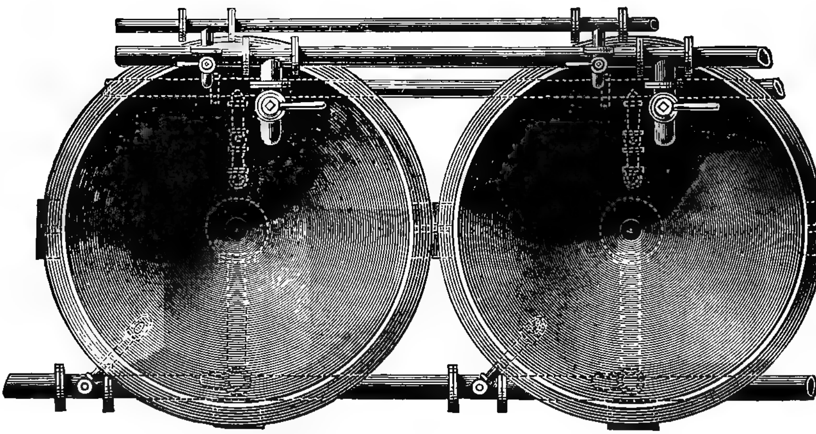


Plate XXXV.

The above plates, No. XXXV, show two forms of defecators made by the Colwell Iron Works, New York, made either with cast-iron, wrought iron, or copper, with double bottoms, as shown in one plate, or with copper coils, as shown in the other plate.

These vessels can be used as clarifiers, if needed; but it is objectionable to have a vessel of too great a depth. Therefore, the vessels represented in Plate XXXVI are recommended, either being as large as occasion requires, and so arranged with a scum trough round the top, that, in the rapid ebullition, the overflowing liquor and scum can be caught, and, by an automatic arrangement of valve, the liquor can be returned to the

main body, while the scum is held in the trough, until a sufficient quantity has gathered to make it an object to ease the steam and wash out the trough.

These vessels are also used as open steam evaporators, having an abundance of heating surface, plenty of high pressure steam, and proper openings for the escape of the condensation; for the water must not be allowed to accumulate in the coils, if rapid and effective work is desired.

The cuts show the necessary pipes and valves for the complete and successful working of the train.

These vessels are also used for reducing the juice to a syrup of 25° B., preparatory for the vacuum pan.

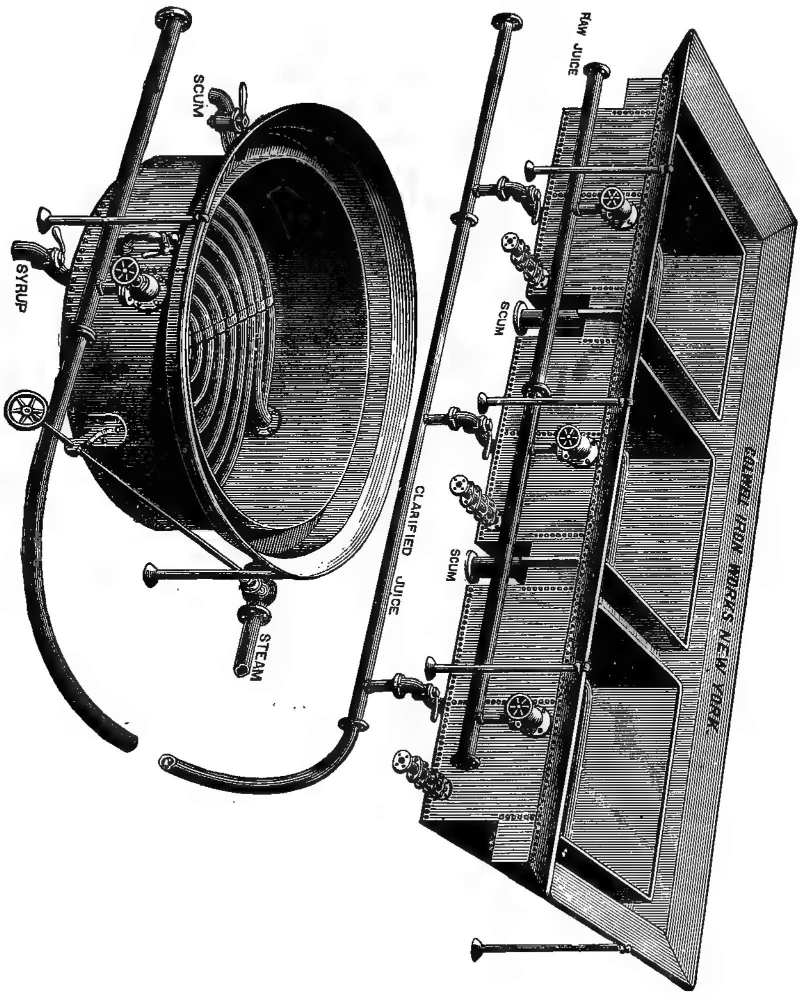


Plate XXXVI.

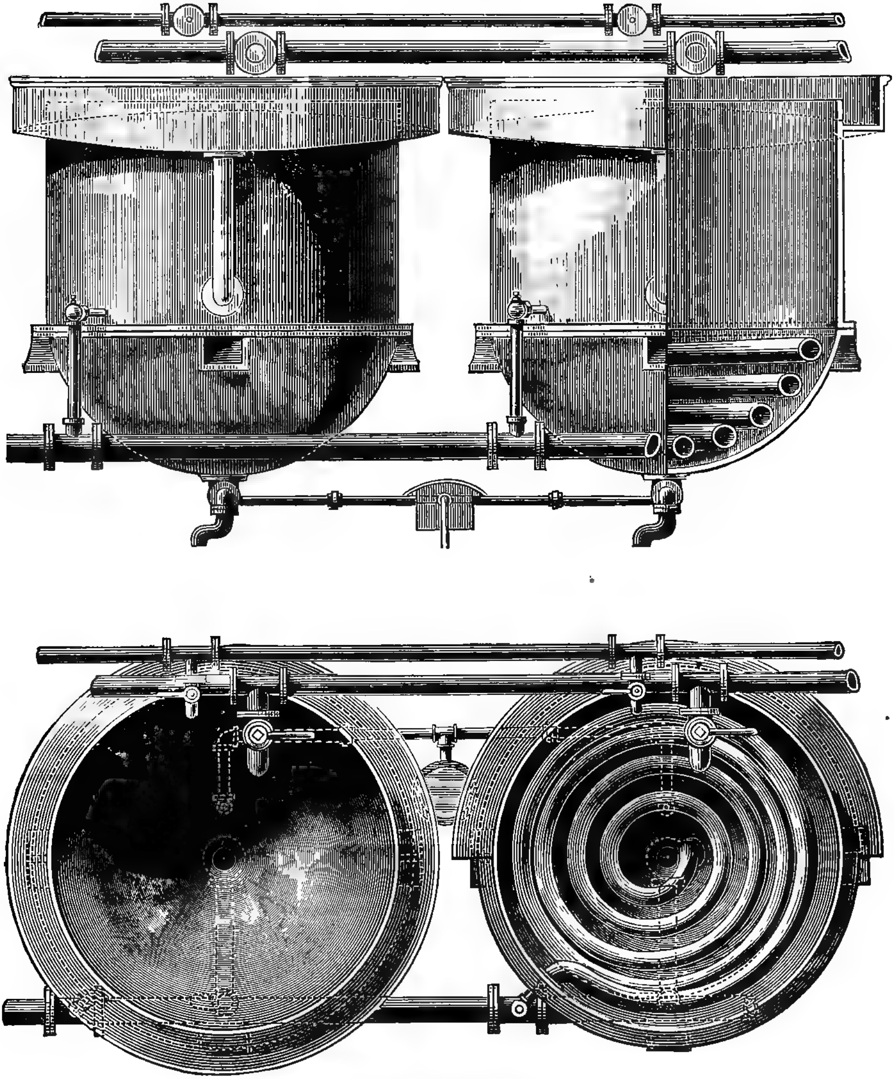


Plate XXXVII.

DIRECT STEAM EVAPORATOR.

Plate XXXVII is a "direct steam evaporator," which receives the clarified juice from the steam clarifier shown in Plate XXXV. The juice is boiled by means of a coiled steam-pipe. The resulting scum boils over into a trough round the upper edge of the evaporator, and is itself subjected to defecation afterward.

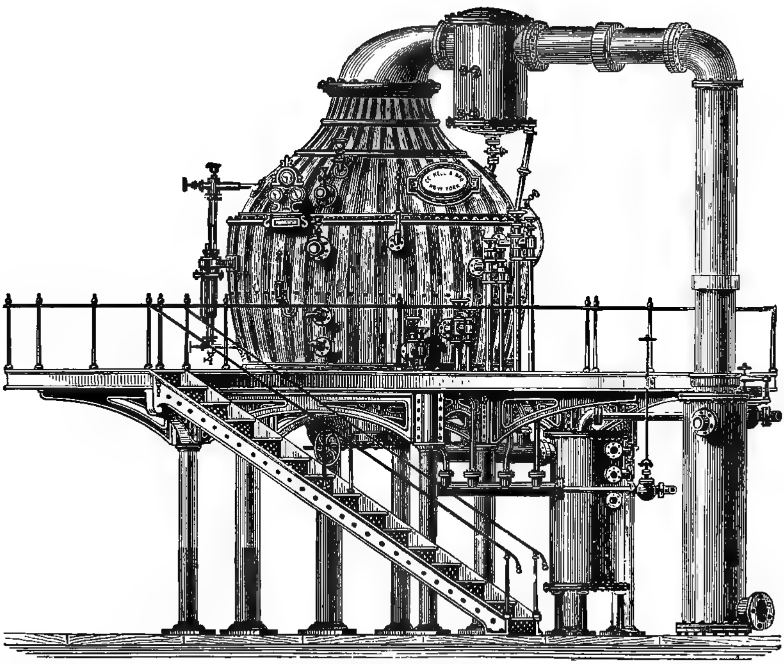


Plate XXXVIII.

ONE STORY VACUUM.—COLWELL.

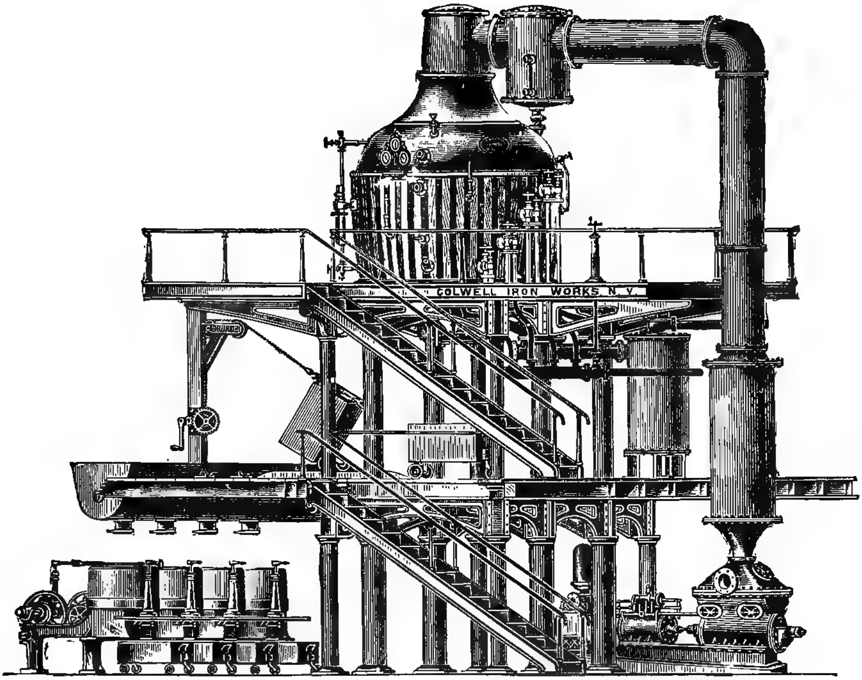


Plate XXXIX.

TWO STORY VACUUM.—COLWELL.

The foregoing plates, Nos. XXXVIII and XXXIX, represent two styles of vacuum pans manufactured by the Colwell Iron-Works, and the following description of the details of their construction, and the mode of their operation has been supplied by the manufacturer:

Vacuum pans are of copper or iron. Copper was once used exclusively, but of late years cast-iron has been the choice.

The heating surface is of seamless drawn copper tubes, in serpentine coils, leaving from three to four inches space between each circle, and inclining to the center, the lower coil following the dip of the bottom, and the upper coil having a dip of about four inches, taking steam on the outside, and leading the condensation out at the center through the bottom to traps—the diameter of tubes depending upon the size of pan.

These coils are secured to cast braces by a cup and cover, which hold them securely from jumping during the boiling, yet allowing them to expand and contract without any strain. The braces are so arranged that they offer but little obstruction to the outflow of the finished sugar (this is a late improvement). Heretofore it was clumsy and strong, or light and weak—in the first place, holding great masses of magma at each strike of the pan; or, in the latter case, when a very stiff boiling is made, the worms were oftimes in a ruin at the bottom of the pan. With our arrangements, the minimum of obstruction and the maximum of strength are obtained. The heating surface is the life of the pan, and if not properly arranged, properly secured, with proper inlets and outlets, the amount of work will not be up to expectation.

Mountings.

Double steam valves, through which the steam is admitted into the coils—principally exhaust steam. That not being enough, live steam can be used at the same time, and yet not exert any back pressure upon the exhaust of the different engines, if properly managed.

Eye glasses, which are placed in curb and dome to see the depth of liquor, as well as the action of boiling.

Thermometer, vacuum guage, which, to be the most accurate, should be columns of mercury. A double-charge cock, with one pipe leading to the syrup tank, and another leading to molasses tanks.

A butter or oil cup, for the introduction of a little oil or sweet butter to check the foaming.

The charge cock has a small cock in its side, called the lime-water cock, for the purpose of correcting any acidity that may occur.

The draw off valve at the bottom is made much larger than formerly, as refiners and planters find it much more economical to boil the pan as stiff as it can be done without getting it too dry (in which

case it will not run from pan without steam pressure from within), many boiling it so closely that in two minutes more it would be liable to set.

For the economical working of a pan, a recipient is furnished. It has many nozzles, so as to connect the exhaust from the various engines in the sugar house, and is connected to the steam trunk with suitable openings, and these in turn connected to the valves on pan by copper pipes. To guard against too much back pressure, the recipient has an escape valve, loaded to a working pressure of about five pounds; and also so arranged that, when the pan is not working, the steam can escape perfectly free.

The recipient also has a water guage and outlet cock.

The condensation of the eliminated vapors of the juice during the boiling, is accomplished in a condenser that is connected to the vacuum pan for the purpose of producing this effect by the injection of cold water, which, coming in contact with these vapors, produces the vacuum desired.

This condensation and injection water is drawn off by means of a large air pump, which, at the same time, takes out any air which may have been admitted through any leaks in the machinery, together with the air which we know to be in the water.

Without sufficient cold water, it is impossible to procure a perfect condensation and a proper vacuum; and, where this occurs, it is impossible to do the work required of the pan.

From 24 to 29 inches of vacuum are considered necessary; and if this is not shown by the mercury gauges, some imperfection exists which ought to be remedied at once.

The operation of boiling is as follows: The juice is elevated into the tanks above by means of a steam pump, from whence the pan draws it. After cooking a strike, which operation lasts from four to six hours, it is thrown out by means of a valve at the bottom of the pan into a mixer (see illustration), which is sufficiently large to contain the entire strike of the pan. Afterward, the sugar passes from the mixer to the centrifugals through a valve opening into each of the machines, where it is purged, ready to be emptied into either boxes or hogsheads, and sent to market. This system is called purging "hot," and is used to-day in all the refineries of the United States and on many plantations. For raw sugar, the vacuum pan can be made to operate on the "wet" or "dry," system. The latter, which is the most modern, is preferred by all who thoroughly understand the matter, but it requires more water. A plantation having complete machinery will make six thousand barrels of sugar with greater ease and less labor

than will be necessary on another plantation to make three thousand barrels where the fire trains are used.

The advantage of the vacuum pan system, in respect to expense of fuel, is immense; as the vacuum pan is worked by means of exhaust steam from the various engines and pumps of the sugar house, thus taking advantage of the latent heat in the boiling of the sugar, after the steam has done its duty as prime mover.

Thus it will be seen that the employment of the vacuum pan and triple effect does not materially increase the amount of fuel necessary for the engines.

The situation of the pan in the house is important, for upon its position depends the economical working of the sugar house.

Employing this system, the planter can have packed in boxes or barrels, and many times in the market each day, the sugar made on the previous day. With the vacuum pan only can be obtained a grain of sufficient consistence to resist the extraordinary expulsive force of the centrifugal.

With a well arranged boiling house, it is not necessary to touch the juice after it leaves the mill until sugar, dry and well purged, comes from the centrifugal, which all planters must acknowledge is a great economy of labor, time, and money.

The pans can be put upon the beams of building, but the better way is to place them upon iron columns and platform, independent of building, so they will not be shaken by the high winds that visit sugar countries.

In the vacuum pan system, the amount of fuel saved is considerable, and the difference in the amount of molasses obtained from a given amount of juice is as 2 to 3—that is, the train produces three hogshead of sugar and one of molasses; the vacuum pan produces five, or even seven, hogsheads of sugar to one of molasses.

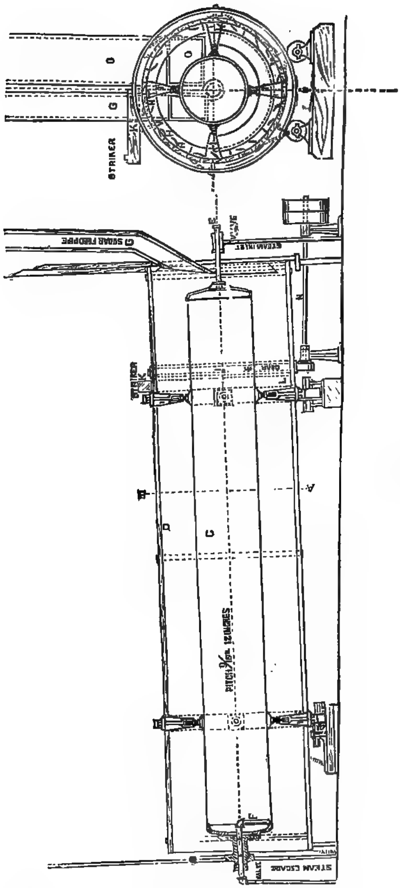


Plate XL.
GRANULATOR.

Plate XL represents a sectional view of the Hersey Granulator.

The sugar is fed in on end through the spout by a set of rolls placed above the machine; and, by lifting shelves on the inside of outer cylinder, is carried up and dropped in a continuous shower upon the heating cylinder, and rolls off by the rotation of the machine, to be again carried up, working forward to the opposite end by the inclination of the apparatus, and is then delivered into the screen for separating into the different grades.

The heater cylinder is put centrally within the iron conveying cylinder, which is 23 feet long and 6 feet in diameter, the heater cylinder being 20 feet long and 36 inches in diameter, and making five revolutions per minute; a striker jarring off any sugar that may adhere to

the cylinder when first entering the machine, which is operated by cams. The machine is rotated by means of outside gear on the convey cylinder.

The current of air constantly passing through the machine carries off the moisture from the sugar through a pipe, and the dry sugar is delivered cool from the end into which the cold air is passing, so that it does not cake, and can be immediately barreled, and will not cause the barrels to shrink.

The following calculations of the practical workings of the vacuum pan, are from the Encyclopedia of Chemistry, Vol. II, p. 903, Lippincott.

"If 30,000 pounds of sugar containing 10 per cent of water, are produced in 2 hours from pan-liquor containing 50 per cent of water, equal to 27¼° Beaumé of density, then 27,000 pounds less 3,000 pounds of water would be evaporated, which, at 28° vacuum, would equal 5,333,334 cubic feet of vapor, and the velocity of this vapor through a pipe of two feet in the cross section, would be 741 feet per second.

If the condensing water was at the temperature of 60°F., and should escape by the vacuum pump at a temperature of 90°F., 24,000 pounds of steam would require 84,480 gallons of water for condensation, or 1 gallons of water evaporated would require 28 gallons of water to condense it.

The steam needed to evaporate 24,000 pounds of water in the vacuum pan, would be, at 30 pounds pressure above the atmosphere, 28,208 pounds, without any allowance for waste.

An open pan would require only 14 per cent more heat to evaporate the same amount of water."

It will thus be seen that the advantage of the vacuum pan (and it is unquestionably great) is not found, as is by many urged, in its saving of fuel or steam, for that is small, and, besides, the apparatus is expensive, and requires expert supervision.

The vacuum pan enables the juice to be concentrated at a low temperature, thus preventing burning entirely, and the inversion of the sugar to a great degree.

The heat of the vacuum pan is generally the direct steam from the boiler, but, on account of the low temperature necessary to secure active boiling, it has been found economical to use the waste steam of the sugar mill in the coils. As an improvement upon the vacuum pan, there have been devised what are known as the double or triple effects, to be shortly described.

In order, also, to avoid the effect of high temperatures upon the sugar, an apparatus similar in construction to the Cook Pan, see page

330, has been employed, with the sides and partitions higher, so that a depth of juice may be secured sufficient to cover a pipe through which hot water circulates, by which the evaporation is kept up. In like manner, hot water has been employed in the coils of the vacuum pan, thus avoiding all danger of burning, which, by using steam, may occur when the vacuum is not well kept, as through an insufficient supply of condensing water. Even in the vacuum pan, the steam generated by the hot surface of the coils is yet under the pressure of the superincumbent mass of syrup, which would be approximately $1\frac{1}{2}$ pounds pressure, equal to 3 inches of mercury, for two feet depth of syrup above the heated coil. It is obvious, therefore, that the pan should be shallow in order to secure evaporation at the lowest temperature; but, in practice, it has been found to give better results in crystallization, by increasing the depth—a result which may be due to the greater freedom of motion of the contents of the pan, which the higher temperature and the escape of steam from a greater depth insures. We have seen that sugar is soluble in all proportions in water; or, rather, that the amount of water necessary to dissolve sugar depends upon the temperature, see page 336. If, therefore, the water which is present in a solution of sugar be evaporated by boiling in an open vessel, it will be found that, as the water evaporates, the temperature of the boiling liquid will gradually increase, and the degree of concentration may be very accurately determined by means of the thermometer. See page 336.

No crystallization of sugar, therefore, can be secured in the open pan so long as the boiling is continued; but it is found, after the concentration has been carried to a certain point, that the amount of sugar is so much in excess of that which the water present is able at ordinary temperatures to dissolve, that, if a portion of the boiling syrup be taken from the pan, the crystallization of the sugar is almost instantaneous, and it is by means of a few simple tests that the experienced sugar-boiler in charge of the Jamaica Train is enabled to tell, when the contents of his battery or strike pan are ready to be transferred to the crystallizing vessels.

The method which is difficult to describe, but which is very simple in practice, commonly employed, is to remove a portion of the boiling syrup by the ladle, and observe its character and appearance, as the last and partially cooled portion runs off; or, by taking a drop of the syrup between the thumb and fore-finger, gradually opening them and observing the string of syrup formed, which, if of the right character, may be extended to about an inch and a half before parting; the broken end partly curls up, while the string presents

a granular rather than a glassy look, showing the presence of the minute grains of sugar which are formed during the cooling.

Another method is to observe the character of the escaping steam, which no longer is continuous, but, as the time of striking for sugar approaches, is in large bubbles, escaping with a puff much resembling the boiling of hasty pudding, or the last boiling in making maple sugar.

In the vacuum pan, however, after a certain degree of concentration is reached, the temperature is no longer sufficient to hold all the sugar in solution, and the excess is at once thrown down in the form of an infinite number of microscopic crystals distributed through the boiling mass. The appearance of this grain is carefully watched for by the sugar-boiler; and, after its appearance, the contents of the pan and the progress of the evaporation receives his constant supervision. The object to be secured is now, by repeated additions of "pan-liquor" (as the semi-syrup, with which the vaccum pan is at first charged and afterward fed, is termed), to "build up," as they say, the small crystals of sugar, or "grain," until they are of appreciable size, so that their purging in the centrifugal may be easily accomplished. The dangers are that, either through increased heat in the pan, by partially losing the vacuum, or by the two great amount of pan liquor admitted in a charge, and the consequent considerable dilution of juice, he may lose the grain by its being dissolved, and he must again recover it, as at the outset; or, by a too rapid evaporation, and the consequent excessive deposition of sugar, it may happen that the sugar is thrown down more rapidly than it can be deposited upon the crystals already formed, and a fresh crop of crystals is produced, known technically as "false grain."

This "false grain" is very carefully guarded against by the sugar-boiler, and may be dissolved by a heavy charge of pan-liquor and a high heat in the pan. But it may happen when the pan is already so full as to forbid further addition of fresh liquor; in which case, it can only be removed by means of heavy washing with water in the centrifugal or mixer, thus causing a great loss of sugar in the molasses.

In working the vacuum pan, the vacuum is first created by the pump, when the semi-syrup is drawn into the pan, until the first coil of pipe is covered, when the steam may be turned into such coil, and, as the successive coils become covered with the syrup, steam is admitted to them. It then remains only to add fresh portions of the semi-syrup as evaporation progresses, until the grain is formed, when the exercise of more care is needed. After a time the full capacity of the pan is reached, and it is then necessary to remove the contents of the pan,

wholly or in part, into cooling or crystallizing tanks, which, being on wheels, are conveniently brought under the sliding gate at the bottom of the vacuum pan; and as they are successively filled, they are wheeled into a warm room, where they are allowed to remain for a few hours, or even a day or two, during which time more of the sugar will crystallize.

In "striking" the pan, as the removal of its contents is termed, the steam is first turned off, the vacuum is broken, the pump stopped, and the contents discharged. It is, however, often the case, that but a portion is removed, and that then the boiling is resumed, supplies of pan sugar being drawn in from time to time, as before. Of course this results (in case no false grain is produced) in the increase in the size of the crystals of sugar; and they are often obtained, by the repeated partial striking of the pan, at last with a diameter from one-sixteenth to one-eighth of an inch. But this "doubling," as the operation is termed, is only possible with very pure juices, as of the best sugar-cane, since the impurities of the juice are gradually accumulating in the molasses, and finally become so abundant as to make purging of the sugar difficult, if not impossible. If such "gumminess" of the molasses is not excessive, a little lime-water drawn into the pan during boiling, is said to remove it; but when it is such as to seriously interfere with the purging of the sugar, the strike of the vacuum pan should be complete, and the pan should be charged with fresh liquor, as at the outset. The danger of false grain being produced, is especially great when, after a partial strike, a fresh portion of pan-liquor is drawn into the pan.

During the entire operation, the interior of the pan may be observed through the glasses in its side, and its contents examined, from time to time, by means of the proof-stick.

MULTIPLE EFFECTS.

On account of the low degree of heat necessary to secure evaporation in the vacuum pan, an important modification has been made by the employment of what are known as *double* and *triple effects.* These are, in fact, a series of two or three vacuum pans, connected with each other; the first being heated, as usual, and the steam from it being used in the coils of the second pan, which practically plays the part of a surface condenser for the first pan. In like manner, the steam from the second pan passes into the coils of the third, which, in its turn, acts as a surface condenser to the second pan. Finally, a condenser and vacuum pump is connected with the last pan of the series, as to the ordinary single vacuum pan. It is claimed that, by this arrange-

ment, great economy is secured in the use of fuel, and that the expense of attendance during the concentration of the juice is greatly diminished.

The saving of labor secured by the employment of triple effect apparatus, as shown in the working of two similar estates, is as given in "Sugar Growing and Refining," page 271, as follows: The syrup and sugar produced upon each estate were said to have been identical in quality and value, and both were under equally able management. On the estate using open evaporators and a single vacuum pan, the labor amounted to 58 men for 18 hours per day, or 1,044 hours per day; while the second estate, using a triple effect and vacuum pan, required, per day, 40 men for 13 hours, or a total of 520 hours of labor per day—a saving of labor, as will be seen, of one-half. Each factory turned out daily 13 tons of first and second sugars. The additional expense of the plant is obvious; but if this saving may be counted upon as possible, the employment of this triple effect appears by far the most economical. Only such juice as has been purified to such a degree as to yield no impurities upon further concentration, is adaped for use in the triple effect, since it is impossible that these can be removed by skimming. The several pans of the triple effect are connected with each other in such way as to enable the contents of the first to be drawn into the second, and the second into the third, as the proper degree of concentration is attained in each.

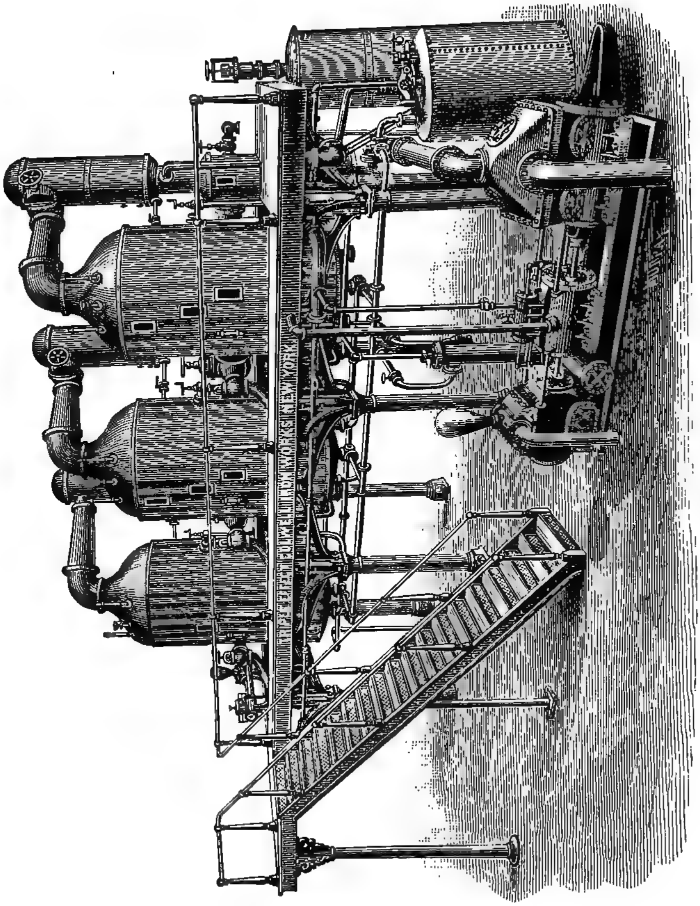


Plate XLI.

TRIPLE EFFECT VACUUM.

Plate XLI represents a triple effect evaporating apparatus, as manufactured by the Colwell Iron-Works, many sets of which are in use upon sugar plantations, as also in the manufacture of beet sugar. The triple effect is the most economical method of evaporation, as it is all done in vacuum. A general description of this apparatus is as follows:

It is composed of three cast-iron vacuum pans, so arranged that the vapor generated in the first pan passes to the heating surface of the second pan, where it boils the liquor; and the vapor thus generated passes to the third, where it boils the syrup; while the vapor from this third pan passes to the condenser, and is drawn off by means of the vacuum pump. The first pan receives its steam from the exhaust steam recipient, which also supplies the vacuum pan.

By this method, there will be required only thirty-five per cent of the steam and water for the proper operation of these pans which would be necessary were all the evaporation done in a single vessel; but this method of evaporation will only hold good on liquor up to 28 or 30° Beaumé.

The interior heating surface of these pans consists of two-inch copper tubes, expanded into composition heads, which are properly secured in the lower curbs of the pans. There is also a suitable large circulating pipe. The mountings of the pans are about the same as in the vacuum pan. By a system of valves and vapor pipes, any of the pans can be connected directly with the condenser at will, thus making it single, double, or triple effect.

The course of the liquor is as follows:

The pump upon the left of the cut draws the defecated liquor from the deposit tanks, the speed being so regulated that the pan is kept at a certain level, the vacuum being about 5 inches and the heat about 180° F. It is here evaporated to about 15 or 16° Beaumé, and, by means of a discharge cock and pipe, is fed into the second pan in such a quantity as to maintain a fixed level. It is here reduced to about 20° Beaumé, and a temperature of say 150° F., and, by means of a discharge cock to this pan, the third pan is supplied in the same manner. Here the concentration goes on till at the finishing point, 25 to 28° Beaumé; then, by means of the condenser and vacuum pump, the necessary vacuum is maintained, in order to finish at as low a temperature as possible. It is now drawn off by means of a montjus, or pump, and passes to the clarifiers.

The operation is continuous, provided there is a proper supply of defecated juice.

The saving of fuel and labor by this method over the steam or fire trains is one of the great incentives in adopting this large piece of ma-

chinery. The quality of the sugar from the juice evaporated in vacuum, and the greater quantity of sugar, or, more properly speaking, the smaller quantity of molasses that can be obtained by this over the fire system, is another and very important reason for its adoption.

If necessary, the vacuum pan, triple effect, and the different circuits of juice and water about the house, can all be operated by one engine, under the immediate control of the sugar master.

Concretors.

In each of the evaporators thus far described, the object has been the concentration of the juice after defecation to a syrup, from which the sugar, after crystallizing, may be obtained, by either draining off the molasses, as with the muscovado, or open pan, fine grained sugars, or by removing the molasses by means of the centrifugal machine, as is done with vacuum pan large grained sugars.

But, owing to increased expense and trouble attending the production of sugar upon the plantation, and the greater economy which attends the extraction of sugar where larger and improved apparatus and greater skill in supervision is secured, many attempt only the production upon the plantation of what is known as "concrete," i. e., the defecated juices evaporated until, upon cooling, it solidifies to a mass, which may be shipped readily, and from which the refiners may readily extract the sugar. This concrete contains, of course, all the impurities which remain in the defecated juice and are not removed by skimming in the production of the concrete.

In principle the concretor may be likened to a Cook Pan, by means of which the defecated juice is allowed to flow over a long trough, exposed, during its flow, to a heat which at first is sufficient to boil the juice and raise the scum, and is afterward diminished so that the juice, when at a density of about 25 to 30° Beaumé, is not heated even to 100° C. Generally, the time required for the concentration of defecated juice to 30° Beaumé is from 8 to 10 minutes. The syrup thus obtained is, by means of revolving discs, similar to those described under Surface Evaporation (page 339), still further evaporated. This last evaporation is rendered more rapid by means of hot air, which is forced by a fan over the film of syrup upon the discs, the last evaporation being accomplished at a temperature below that of boiling water. Scrapers continually remove the solidified juice from the discs. The "concretor" is also used for the purpose of reducing the juice, after defecation, to pan-liquor, for which it is well adapted: in this way taking the place of the ordinary evaporators used for this purpose. It would seem that the use of the concretor and the preparation of con-

crete for some central factory or refinery was worthy of careful consideration by those who are unable to enter upon the expense of a sugar house, since this concrete may be kept a long time, can be shipped without loss, and worked for sugar when convenient. Its market value would, of course, be largely dependent upon its content of sugar; but it could easily be worked over for syrup. By thus simplifying the necessary work upon the farm, in the preparation of a marketable article, it offers unusual facilities to those entering upon this new industry with little experience and limited capital. In all the methods thus far described for the removal of water from the saccharine juices and the separation of the sugar, heat has been always the agent employed; but, to the chemist and the physicist, cold presents itself as an agent well calculated to accomplish the same result, and possessing certain great advantages in its employment.

Already this agent has long been considered as practically available, and numerous experiments have been made to render it effective; but thus far no practical results appear to have been realized.

One pound of water at 70° F. loses 38° in passing to the freezing point, and in the act of freezing must part with 140° more of heat; or, in other words, to freeze one pound of water at 70° F. requires the removal of heat enough to raise 178 pounds of water one degree.

On the other hand, one pound of water at 70° F. requires 142° of heat to raise it to the boiling point; and, to convert it into steam, requires an additional 966°.6 of heat; or, in other words, to convert one pound of water at 70° F. into steam at 212° F. requires as much heat as would suffice to raise 1,106.6 pounds of water one degree in temperature.

It appears, therefore, that the relative energy required to freeze or boil water at 70° F. is as 178 is to 1,108.6, or as 1 to 6.23. In evaporation, the energy developed in the combustion of wood or coal, for example, is applied directly, and, although, through radiation, conduction, and the various imperfections of the furnace, much of the energy is lost—so far as effective work is concerned, such loss may be reduced almost to its minimum; but, in the several transformations necessary to apply the energy developed by burning coal, through steam boilers, engines, pumps, and so forth, to the freezing of water, the inevitable loss seems to more than counteract the apparent advantage the latter operation has over the former.

One pound of coal will evaporate about nine pounds of boiling water, equal to 7.85 pounds of water at 70° F.; and it is claimed that one pound of water may be frozen by the combustion of three pounds of coal under the boilers of the refrigerating apparatus. But, despite this

unfavorable showing, there are so many advantages to result from the use of cold in concentration, that it is well worth careful investigation, and it is scarcely improbable that, through improved appliances, such a process may be made practical. The fact that crystallization is a means of purification, owing to the crystal during its growth excluding all foreign substances, has been referred to, page 326.

The formation of ice, which is simply the crystallization of water, is not an exception to this rule. The concentration of cider and of vinegar by the freezing of a portion of water are familiar examples. This method of concentration has been extensively used in the preparation of salt from sea water in Northern Russia, shallow pits being dug upon the shore, into which the sea water is admitted and allowed to freeze, the ice which forms being nearly pure water. The unfrozen portion is thus concentrated to such a degree as to make further concentration by heat economical.

SEPARATION OF THE SUGAR FROM MOLASSES.

After the concentration of the juice has been effected, it is necessary, if the open pan process has been used, to let the syrup remain in coolers or cystallizing tanks until the sugar has had time to separate in crystals. The time required for the completion of this process depends upon the character of the syrup. In case the relative amount of glucose and other impurities is small, and the syrup thin and liquid, a day or two will suffice; but where the amount of sugar is relatively small, the syrup stiff and viscid, weeks, or even months, are necessary to complete the crystallization. It is found that the slower the crystallization the fewer and larger the crystals, and, in some instances, crystals over an inch in diameter have been produced. The production of rock candy is a case illustrating this.

Crystallization is facilitated by keeping it in warm rooms, as the heat renders the syrup more liquid, and gives freedom to the particles of sugar.

Crystallization is more rapid from shallow coolers (6 to 10 inches) than from those of great depth (2 to 3 feet), but, when rapid, results in a mass of fine crystals difficult to free from the molasses, while the crystals from the deeper vessels are larger. If the concentration has been properly conducted, there will always be after crystallization a mass of sugar crystals distributed in the molasses.

The separation of this molasses is accomplished in a variety of ways. The common muscovado sugar, obtained by boiling in the Jamaica Train or open pan, was drained of its molasses by throwing the mass of sugar and molasses from the coolers into hogsheads, arranged so

that the drippings from them could be received in a large tank. In the bottom of the hogsheads holes were bored, which were kept open, and, in time, a large portion of the molasses would slowly drain off, leaving always a considerable portion still adhering to the crystals of sugar. It was thus sent to market as a soft-grained, moist, yellow or brown sugar, the color being due almost entirely to the adhering dark colored molasses. Another method suitable for the extraction of sugar upon a small scale, is to put the "mush sugar," as the mixture of sugar and molasses may be termed, into strong bags of a somewhat loose material, and subjecting them to pressure, at times taking out the bags to work over their contents, and pressing again.

Claying.

The fact that the color of the raw sugar was found to be due to the film of molasses adhering to each crystal, which neither draining nor pressure could entirely remove, led to the washing of the sugar with water. This was accomplished by placing the concentrated syrup or mush sugar in earthen molds, shaped like an inverted cone. At the bottom a hole, which was stopped until crystallization of the contents was completed, allowed the molasses to drain away. When this was completed, a layer of straw was spread on the sugar, over which a stiff paste of clay was put, the moisture from which, slowly percolating through the mass of sugar crystals, washed off the coating of molasses and left the crystals nearly white. Instead of clay, a piece of felt or other heavy cloth was often used.

Of course, much of the sugar was dissolved by this process, and the claying was discontinued before the entire contents of the cone was made white; so there came to be recognized in the trade different brands of clayed sugars, according to the portion of the cone from which they were taken. The dried cones were cut into portions horizontally, the upper and whiter being termed in French trade premier, next second, then troisieme, petit, commun, and tete, the latter being the still black sugar from the apex of the cone.

These sugars have been largely made in the French colonies, China, and Cuba; and the "Havana sugar," so common in our own markets twenty years ago, was a clayed sugar.

At one time, it is said that there were four hundred plantations, in St. Domingo alone, which made clayed sugars.

Centrifugals.

The most convenient (and, at present, almost universal) method for the separation of the molasses from the sugar, is the centrifugal ma-

chine, introduced in 1843. It consists of a cylindrical vessel, about three feet in diameter, revolving upon an upright shaft. The outer portion of this cylinder is of wrought iron, pierced with numerous small holes. Within this, and lying against it, are one or two screens of wire gauze. This is inclosed within an outer cylinder of iron, of a diameter six or eight inches greater than the revolving drum within. The wire basket (which has an opening at the top for the introduction of the charge, and trap-doors at the bottom for the removal of the separated sugar) is connected by a belt, etc., with an engine, by which it is made to revolve from 1,000 to 1,500 times a minute, thus giving at the circumference a velocity of from two to three miles a minute, for a centrifugal three feet in diameter. The mixer is a long, half cylindrical vessel, into which the mass of sugar and molasses from the coolers is emptied, and where (by means of a series of revolving arms, attached to a shaft running lengthwise in the mixer) the contents are stirred into a homogeneous mass. From this vessel (which, for convenience, is placed directly over, and discharges through a sliding valve its contents into the centrifugal) a charge is introduced after the centrifugal is set in motion, but before it has attained its maximum velocity. The centrifugal force distributes the mass equally over the gauze periphery, and the molasses forced through is caught by the outer drum, and collected in a receiving tank placed below. So soon as the molasses has been separated, a spray of water is thrown upon the surface of the sugar, and the residual molasses is thus removed. A jet of steam is sometimes introduced upon the outside of the perforated drum, to aid in the ready removal of the molasses; and, after the washing, hot air is drawn in upon the sugar to dry it. Ordinarily from five to fifteen minutes suffices to purge one charge, although the character of the mush sugar introduced is sometimes such, that a far longer time is necessary.

Vacuum pan sugars, being made up of larger crystals, are far more easily purged than the softer, finer grained, open pan sugars, and the purging of such coarse grained sugars is accompanied with less loss of sugar. The injurious effect of false grain is here manifest, since it tends to block up the meshes of the gauze, and thus prevent the expulsion of the molasses. The treatment of water, therefore, either in the mixer or in the centrifugal, for the purpose of dissolving these minute crystals of sugar is rendered necessary.

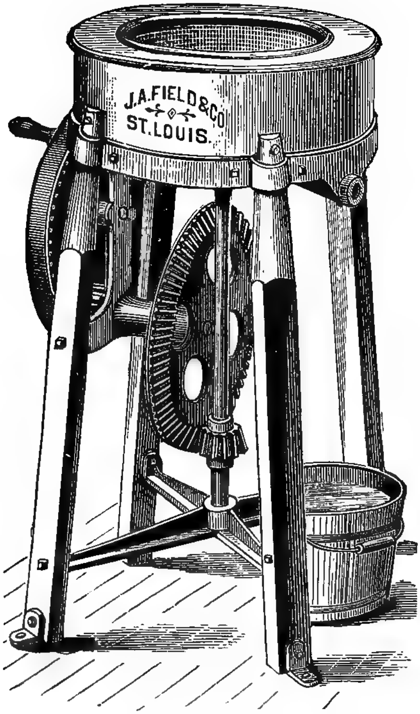


Plate XLII.

No. 1. Hand, 18-inch disk. Capacity, 60 pounds per hour.
Same, for belt. Capacity, 100 pounds per hour.
Same, combined for either belt or hand.
Power machine, 24-inch disk. Capacity, 250 pounds per hour.

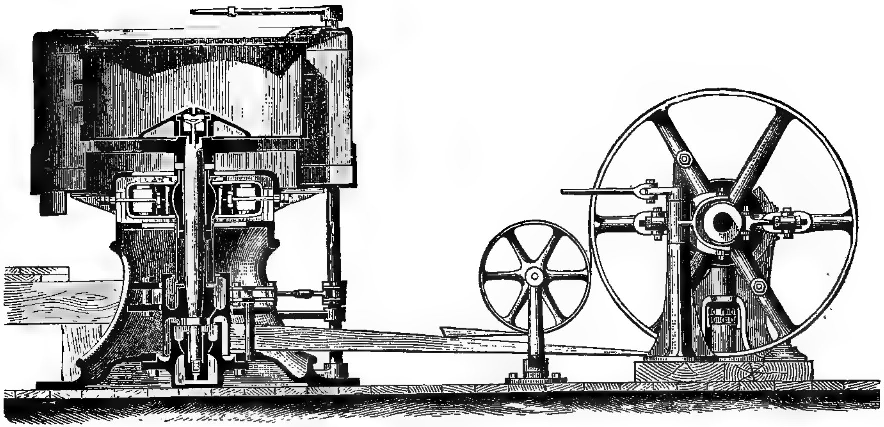


Plate XLIII.

"GERMAN STYLE" OF CENTRIFUGAL MACHINE.

In this machine the sugar must be taken out at the top, as there are no openings in the bottom. It runs in elastic bearings, and does not require to be set on masonry. It is claimed that it will drain from 1,000 to 1,500 pounds of sugar per hour.

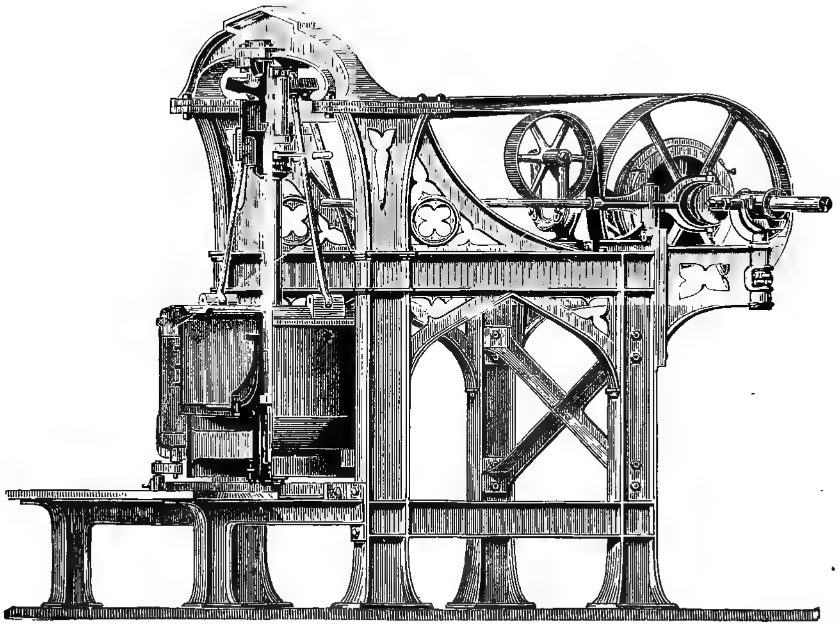


Plate XLIV.

HANGING CENTRIFUGAL.

Plate XLIV represents the Hanging Centrifugal Machine, especially adapted to gummy sugars. It discharges the sugar at the bottom, and it is claimed that it will purge from one to two tons of sugar per hour,

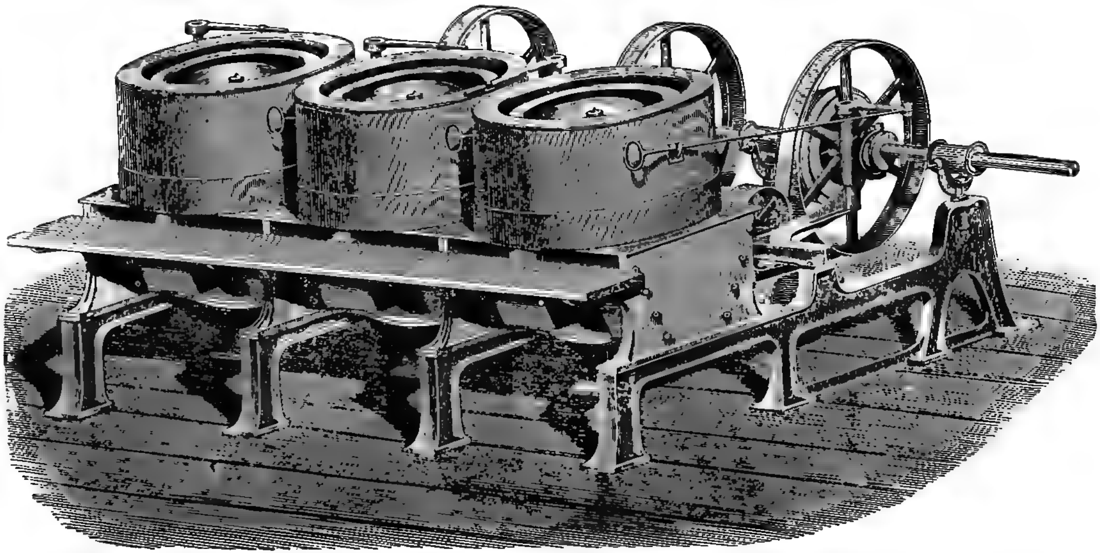


Plate XLV.

IMPROVED CENTRIFUGAL.

The machines, plate XLV, are arranged, and can set on an ordinary floor; are entire self-contained by substantial iron frames. Fitting at the top, there is no shaft to interfere with its easy and perfect manipulation, It is discharged at the bottom, and the sugar received in a car. The belts are all underneath, and thoroughly protected from drip. This is a great improvement upon the overhead belts, where, if a belt should break, the lives or limbs of the men are endangered. These machines are steady, better balanced, and in every way superior to the German standing machine, or the hanging machine.

Molasses.

Molasses is the name given to the liquid product which is, by either of the processes given, separated from the sugar.

In speaking of "available sugar" in a juice or syrup, it was explained that the glucose and inverted sugar present in a syrup would prevent its own weight of sugar from crystallizing; also, that some of the mineral matters present in the syrup, exerted a similar action in holding the sugar in solution. Molasses, then, is a mixture containing in solution all those impurities originally present in the juice, which were not removed in defecation or skimming, and the sugar which has been held in solution by such impurities. It generally holds in solution a certain amount of sugar which was not removed in the first crystallization, and this is often so great as to warrant the molasses being boiled in the vacuum pan a second, or even a third time for sugar. These successive crops of sugar thus obtained, are called seconds or thirds, and the molasses from them is also termed second and third molasses.

Of course, each additional quantity of sugar taken from the molasses only serves to concentrate the impurities more and more, so that the last molasses are almost worthless, except for distillation into rum, or for the production of spirits. In the crude operations of the sugar plantations, the amount of sugar left in the molasses is so great, that large quantities are imported and worked over by the refineries; and the residual molasses, purified by the bone-black filtration to which it is subjected, is rendered still a very acceptable commodity for domestic use.

The average percentage composition of a molasses, when all the sugar which will crystallize has been obtained, is nearly as follows:

	Beet molasses.	Cane molasses.
Cane sugar	55.00	35 00
Organic matter not sugar	13.00	10 00
Glucose	trace	30 00
Water	20 00	20 00
Ash	12.00	5 00
	100.00	100 00

We have then from the above, the "available sugar" from the cane as equal to the cane sugar or the sucrose, less the sum of the glucose and mineral matter, since, in practice, it appears that the sum of these above represents the amount of sucrose held in solution in the molasses.

If, then, as is most probable, the juices of sorghum and maize are comparable with the juice of sugar-cane in this regard, it will be seen that our estimate of available sugar has been placed too low, since, in every

24

case, we have also considered the organic matters not sugars as capable of holding in the molasses their own weight of sucrose, while in the cane molasses this is seen not to be the case. On the other hand, the molasses from sugar beets is found to contain but slight amounts of glucose, but a very much larger amount of sucrose, and this is held in solution by the ash present, composed largely of potash salts, which have been shown by the experiments of Marschall and La Grange (La Sucrerie Indiginie, X., 259) able to hold from 3 to 6 times their weight of sugar in the molasses.

SUCRATES OF LIME AND STRONTIA.

In the manufacture of beet sugar, owing to the fact that the molasses is of such quality as to unfit it for any domestic use, efforts have been made to secure from it the crystallizable sugar which it contains, and one of the most successful methods has been to combine the sugar with lime, to form the basic sucrate of lime, which may be then separated from the glucose and other impurities of the molasses, and from this sucrate the sugar is obtained by converting the lime into carbonate of lime, and thus setting free the sugar.

Since this process has been by some recommended as one by which the sugar from sorghum or maize stalks might be procured readily, in a condition such as to enable it to be sent to central factories, or become an article of commerce, the process of its preparation will be given. The compound of sugar and lime is known as the tri-basic sucrate of lime, and consists, when pure, of one molecule (342 parts by weight) of sugar, and three molecules (168 parts by weight) of lime,or 67 per cent sugar and 33 per cent lime.

Its preparation from molasses or syrup is as follows: The molasses is mixed with about one-quarter its weight of lime, when the mass solidifies, and, after cooling, it is broken up and washed with water, by which the greater part of the impurities are removed, the comparatively insoluble sucrate of lime being left behind. But, owing to the partial solubility of the sucrate, much of the sugar is thus lost, and, instead of water, alcohol of about 35 per cent is used to wash the mass, the alcohol being again recovered by distillation. It is necessary to have lime sufficient to fully saturate the sugar present, since several other compounds of lime and sugar may be formed which are far more soluble than the tri-basic sucrate; and besides this compound, while comparatively insoluble in water, is readily soluble in a solution of sugar. Owing to the ease with which it would seem that this compound might be prepared, its convenience for shipping or storage, since it is said to keep unchanged for long periods, it is to be hoped that ex-

periments may soon be made to determine the exact method of procedure, by which the small farmer could convert the juice of his sorghum into a permanent, portable, and commercial product, without the trouble and expense of trying to make sugar.

Sucrate of Strontia.

Professor Scheibler, of Berlin, Germany, has recently patented a process, for the recovery of sugar from molasses, in which he substitutes strontia for lime, forming the tri-basic sucrate of strontia, which, like the corresponding lime compound, is afterward decomposed by carbonic acid, and the sugar recovered.

The advantage of this modification is, that the strontia compound is less soluble than that of lime, and it may be more readily obtained free from the impurities with which it is associated in its production.

The details, in brief, of this process, are as follows: The molasses or syrup is diluted to such an extent, that, when heated to a temperature of from 70° to 75° C. (158° to 167° F.), it will dissolve enough of the somewhat difficultly soluble strontia hydrate to form a tri-basic sucrate of strontia, with all the sugar present in the molasses or syrup. Or a solution of the strontia hydrate in water may be added to the molasses sufficient to form the tri-basic sucrate, allowing 364.5 parts by weight of strontia hydrate to 342 parts by weight of sugar present in the molasses or syrup to be operated upon, or 106.6 per cent of the weight of the sugar calculated to be present. The objection to this method of procedure being, that the solution would thus be rendered too dilute, since the strontia hydrate is much less soluble in water than in a solution of sugar.

In practice, the diluted molasses is run into a sheet-iron vessel, surrounded by a steam jacket, and provided with a stirring apparatus, by which the molasses is stirred up with the strontia hydrate, an excess of which has been previously added in the solid condition to the sheet-iron receptacle. So soon as the sugar of the molasses has become saturated with strontia, care being taken that the temperature be not allowed to arise above 75° C., the solution of strontium sucrate, and the other impurities of the molasses, is drawn off into another vessel, leaving behind the excess of undissolved strontia hydrate for a subsequent lot of molasses. This second vessel receiving the solution, is also provided with stirring apparatus, and, in this vessel, the solution is heated to the boiling point, at which temperature the strontium sucrate is deposited from the solution in the form of a heavy sandy powder, which, unlike the corresponding gelatinous and voluminous calcium sucrate, deposits quickly and may be easily filtered. The filtration of the de-

posited strontium sucrate must be effected at a boiling temperature, and is accomplished best by means of the filter press, the last portions of the impurities still in solution being removed by steam, or the strontium sucrate is obtained by means of the centrifugal.

The production of sugar from this sucrate, and the recovery of the strontia as hydrate, are comparatively simple matters.

The cost of the strontium hydrate, and the large amount required to combine with the sugar, forbid this from becoming a process to be employed by the farmer, but there appears to be no reason why it might not be used in large works where the production of the maximum of sugar was desirable.

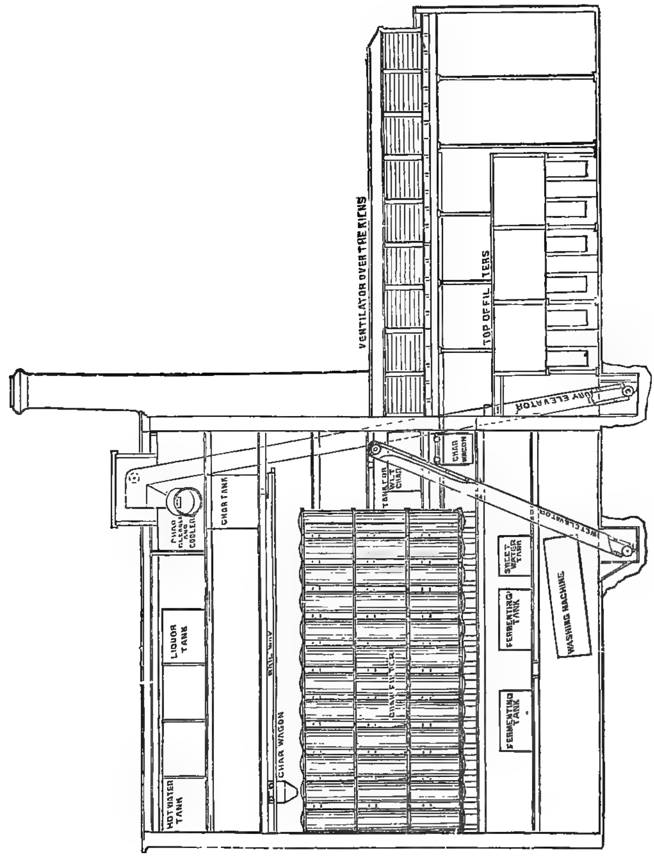


Plate XLVI.
CHAR HOUSE, FILTERS, KILNS, ETC.

The above diagram shows the arrangement of a complete char-house, filters, kilns, etc.

The description of the same was prepared by the Colwell Iron-Works, of New York City. The man-holes at the bottom of the filters are not represented in the plate, since the filters are in two rows with the man-holes opposite the side shown in the plate. The driers, also mentioned in the description, are not represented in the plate, but the general arrangement of this portion of the sugar-house will appear sufficiently clear to the reader.

The char house is acknowledged to be the most important branch of sugar refining, for without it white sugar can not be made to advantage; and to properly revivify the char, much ingenuity has been expended. As many as 172 distinct patents for drying, revivifying, and cooling the char preparatory to filling the filters, have been granted.

The char house and filtering department should be adjacent, so that the spent char from the filters can be delivered in as short a time as possible to the driers on the top of the kilns, and the revivified char from the coolers under the kilns may be transferred to the dusting arrangement and deposit tank for the char over the filters.

We will now follow the course of the char, and suppose it has been received from the filter, and placed in the drier.

The char, in its slow descent through the drier, constantly presents new surfaces to the action of the in-going air, carrying off the ammoniacal gases, and leaves the drier almost at boiling point, so that after a few minutes exposure to the open air it is quite dry on the surface. These driers, when applied to the old style of kilns, have increased the capacity about 25 per cent.

The char is received in a bin, which is directly over the top of the retorts; and, as the char is drawn from the coolers underneath the kiln, the retort is charged; thus being continuous in its action, and requiring no men on the kiln head, trampling, shoveling, turning, and pitching the char about, so as to dry it as much as possible before it enters the pipes; for it is admitted that, without the drier, fully two-thirds of the fuel is consumed to expel the moisture before the char begins to purify, filling the char house with steam and gases, while with the drier it is the best ventilated portion of the house.

The char now passes to the retort pipes which, in the ordinary kiln, are of cast-iron, of an oval pattern, 3 x 12 inches inside set—twelve or more on each side of the fire-place, which is about eighteen inches wide by eight feet long. The retorts are entirely surrounded by a fire-brick wall, outside of which are the flues, into which the gases escape through small holes back of the retorts, Passing up these side flues, they join in front or back and are delivered under the drier into a flue,

where the hot gases are distributed into the pipes of the drier, and through them into the chimney, at a temperature of 380° F., with a great saving of fuel.

After remaining in the retort a sufficient length of time to be raised to a cherry-red heat, the organic substances which have been taken up from the juice are here expelled.

At intervals, the char-slide at the bottom of cooler is opened, and a quantity of char drawn off and tested, which test, proving correct, soon enables the char-burner to tell how much char should be drawn at certain intervals: for if too much is drawn, the char will be improperly burned, and will be unsuited for use in the filters. This can be learned by practice and by test. The cooler is a sheet iron tube, connected with the bottom of the retort, where the char is reduced in temperature to 120° F., and is then received in barrows, or, in large houses, upon an endless carrier apron, which delivers it to an elevator, raising it to a dust box and blower, where the fine dust char is taken away, and the clean char is received in a carrier with inclined shoots, so as to fill the filters quickly and uniformly.

The filters are iron cylinders and usually designed so that the height is six times the diameter, until within a few years, when filters have been made ten feet in diameter and eighteen feet high. The style of filter somewhat depends upon the size of char used, and the manner of working the house, whether very fine grain or coarse char—each size having its partisans, claiming superiority for each. The filter is filled with animal charcoal, and the liquor is let in upon it expelling the air. Great care is necessary that the whole filter should be full, and the juice not allowed to run down on one side only. After the liquor has completely filled the filter, the cock is turned on at the bottom, and the liquor is conducted to the top of another filter, and also to a third, if needed, so the juice passes over a set of two or more, discharging the juice clear and colorless; this goes on until the color grows dark, or is not satisfactory, and they are stopped, the foul filters washed out by letting the water flow in at the top, pressing the liquor out before it, until it does not show a trace of sweetness. The filter is then allowed to drain. Sometimes steam is used, or an exhaust is applied to the bottom to draw off the water—air following to fill the vacuum. The lower man hole is now opened, and the exhausted char conveyed directly to the drier over the kilns by means of a suspended rail car or elevator.

The plate represents the sectional view of filter and kiln house; the car to convey it to the elevator, the elevator to raise it up into the top

of the char house, where it is received upon the drier, through the drier into the cooler, through the coolers to the wagon underneath, where the finished and revivified char is re-lifted back into the filter house and departments as shown.

CHAPTER XI.

(*a.*) Waste products from sorghum.
(*b.*) Seed, composition, and feeding value.
(*c.*) Bagasse, loss of sugar in.
(*d.*) Experiments in saving sugar from bagasse.
(*e.*) Leaves, food value.
(*f.*) Bagasse as food, fuel, and as material for paper.
(*g.*) Scums and sediments, value.
(*h.*) Sorghum as a forage plant.

WASTE PRODUCTS.

By those who have watched closely the development of the beet sugar industry, it is seen that its successful establishment has, in every case, been intimately connected with the most careful attention to details. Not only has the extraction of the sugar from the beet been brought to the limits of perfection, but entirely new methods have been devised, after long years of investigation, for extracting the largest attainable quantity of sugar from the syrup. The greatest attention has also been given to the utilization of the so-called waste products of the manufacture; and where these, as an additional source of revenue, are disregarded, the industry has, at best, barely sustained itself, even in those sections where the conditions appear most favorable. In fact, to such perfection have all the details of the manufacture of the sugar been brought, that the chief care appears to be given to these minor points of the industry. The result is, that the beet is practically the only rival of the sugar-cane as a source of sugar for the world.

It needs but a glance to see that nothing like such minute and careful supervision has been given to the sugar-cane or the sorghum industry.

Millions of tons of sugar have, during past years, been produced from sugar-cane, by processes so crude and methods so wasteful, that it is safe to say, hardly another great industry in the world would survive such burdens of waste for a single decade. At the present, the sorghum sugar industry is setting out mainly in the course laid down by the sugar-cane manufacturers. As the reports from every section of the country unite to show that none of our common farm crops yield so large a profit as does the production of syrup and sugar from

sorghum, it is most important that advantage be taken of every detail: attention to which gives promise of increasing the profit of this new industry.

A discussion of what may be regarded as the waste products of sorghum is of extreme importance, and is given in this chapter.

Among waste products may be classed the seed, bagasse, and leaves, and the refuse products in the manufacture of sugar, viz.: scum and sediment of the defecator, the sediments of the settling tanks, and skimmings from the evaporator.

The most important of these is the seed. For this alone sorghum has, for centuries at least, been grown over a large portion of the globe, as maize is in the United States. The yield per acre of seed is practically the same as maize, and its uses in those countries depending upon it mainly are the same as maize. Analysis shows it to have the same composition, and practical feeding experiments confirm the indications of chemical analysis that it is at least the equal of maize in its feeding value.

COMPOSITION OF SORGHUM SEED.

Analyses of several varieties of sorghum seed have been made, with a view of determining their probable value as food for animals; and, for the purpose of comparison, an average of the analyses of the grain of twenty-one varieties of common field corn is given:

	Early Amber.	Early Amber.	Liberian.	White Mammoth.	Average of the 4.	Average of 21 field corns.
	Pr. ct.	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*
Water	10.50	10.57	9.93	10.90	10.48	9.36
Ash	1.45	1.81	1.47	2.00	1.68	1.54
Fat	4.34	4.60	3.95	4.14	4.26	5.56
Soluble albumen	5.98	7.34	6.90	5.69	6.48	5.93
Insoluble albumen	4.27	2.64	2.64	6.97	4.13	4.97
Sugar	.60	1.91	2.70	.88	1.52	2.20
Gum	.90	1.10	.72	2.20	1.23	2.22
Starch	69.04	68.55	70.17	65.71	68.36	66.80
Crude fiber	2.92	1.48	1.52	1.51	1.86	1.42
	100.00	100.00	100.00	100.00	100.00	100.00

The above analyses show the average composition of the sorghum seed and corn to be in those nutritive constituents which are of value,

viz.: the albumenoids, fats, and carbhydrates, or non-nitrogenous matters, as follows:

	Albumenoids.	Fats.	Non-nitrogenous.	Other constituents.
	Pr. ct.	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*
Sorghum seed	10.61	4.26	71.11	14.02
Corn	10.90	5.56	71.22	12.32

Upon page 97, Annual Report Department of Agriculture, 1879, after a discussion of the market value of the above nutritive constituents, in grains, the following prices are given as being approximately true for our country, viz.:

	Cents per pound.
Albumenoids	4.50
Fats	3.84
Non-nitrogenous	.95

At these prices, 100 pounds of the sorghum seed would be worth $1.32, and 100 pounds of corn $1.38, or practically almost the same.

The above results seem to be confirmed by many in their experiments in feeding the sorghum seed; and, as is well known, this grain has been in very extensive use in China for centuries as food for both man and beast.

In the above analyses, the percentage of starch, as given, is determined by difference; but in the analysis, in the attempt to determine the starch by converting it into glucose, there was a considerable portion which resisted such conversion. In the sorghum seed, this amounted, in the case of the White Mammoth to 17.56 per cent, and in the Early Amber to 19.44 per cent of the grain.

This substance appears incapable of fermentation, is not able to reduce Fehling's solution, and is without action, so far as could be determined, on polarized light. In a sample of corn analyzed there appeared to be only 4.33 per cent of this substance present.

The presence of 5.42 per cent of tannin has been reported in a sample of sorghum seed; but such a composition is quite unique among the cereals, and as this tannin has been detected in no other specimens, its presence as indicated above shows a faulty method of analysis.

The importance of having the value of the seed clearly established is such that the following testimony is presented from those who have given it trial:

Hollister S. Phillips, Mindora, La Cross Co., Wis., reports 22 bush-

els of seed per acre, and says that "108 pounds of seed yielded 66 pounds of flour;" the flour was used in his family from November to the following August.

For griddle-cakes it is nearly equal to buckwheat (some of his neighbors consider it superior), and mixed equally with buckwheat no difference could be detected.

For ginger-cakes it is excellent. As feed for cattle, horses, and hogs, I know it has no equal. There is no grain that will make a horse gain in flesh faster. For milch-cows a farmer can not estimate its value till he has tried it. It is especially valuable for young stock, and calves, and for hogs. I know that it is worth more per bushel than corn, and when I say more I mean that there is a great difference.

In the spring of 1881, we killed a hog that had been fattened wholly on cane seed. The meat was as hard and sweet as I ever tasted. This hog was fed on nothing but cane seed and water, yet it took on flesh faster than any hog I ever fed. Some farmers complain of the expense of harvesting it. Now, does it pay to pick up an ear of corn after it is husked and thrown on the ground? One head of cane seed will yield as much feed as an average sized ear.

Mr. A. L. Talcott, Secretary Jefferson Sugar Manufacturing Company, Jefferson, O., writes:

I have seen a number of questions regarding the use of cane seed flour for griddle-cakes, that can be fully answered from the experience of this company. Cane seed is worth more for flour than for any thing else. It is a great improvement on buckwheat, as it is finer food, and more nutritious. We own a large flouring mill, and have given the question a thorough test, both in 1881 and 1882. The flour is put up in 12 pound sacks, and retailed by our grocers at 50 cts. per sack (same as buckwheat flour). We have also mixed it with oats and ground it up into chop feed. It is as good as corn for feed.

Professor Geo. H. Cook, Director New Jersey Experimental Station, New Brunswick, N. J., reports that

The value of the crop (sorghum) is considered to be mainly in the sugar, but the seed is found to be about equal to Indian corn in feeding value, and the crop per acre is not less than that of other common cereals. There are no good feeding experiments to show what may be the value of stalks from which the juice has been extracted. The field for enterprise in this direction is a large and inviting one.

Col. Colman, of St. Louis, President of the Mississippi Valley Cane Growers' Association, in his address to the sorghum growers of Wisconsin, says:

Where is our advantage in the northern cane? It produces seed, and the experience of the farmers all through our section is, that the amount of seed obtained from an acre of cane is equivalent to the amount of corn raised upon the same area of ground, and the seed is just as good for fattening hogs and steers, and feeding your horses, sheep, and fowls. In Kansas they pay ten cents a

bushel more for it than they do for corn, because it agrees with their sheep better. Here is a crop that really costs nothing. You are paid for the use of your land, for the raising of the crop, in the seed alone, and the cane then can be put at your mills for a mere song. What other sugar producing plant will do the same? Will beets do it? No. Beets do not pay in this country. Labor is too expensive. Every beet establishment in the country is played out. Will the southern sugar-cane equal it? By no means. There is no compensation in the seed there, because there is no seed obtained there. Here is a plant that pays for its own production, and all you have to do is to use your stalks. Capt. Blakeley will tell you that they have told him, at the Rio Grande place, that wherever they have fed this seed at dairies there was an increase of milk. In Philadelphia they will pay 65 cents a bushel for all they can get to feed to dairy stock, and farmers all over the country tell of its great value for feeding purposes. So that if you only got the seed it would pay you; but, in addition to that, you can raise from 10 to 20 tons of product for which you can get two dollars and a half a ton. I would like to know what other crop will bring the farmer as good returns as this?

At this same meeting other testimony was given, as follows:

Mr. Clements.—In our country there are about 3,000 acres of cane raised, and they are as careful in saving the seed as the cane. The results, as to the seed, are equal to corn. We consider it equal to corn, pound for pound.

Mr. Poland.—I feed my horses and milch-cows with it, and make a mush of it for the pigs. There is no one has fatter hogs than we have, just fed on the seed. It is excellent feed; corn has no preference over it for feeding purposes, in my opinion. I do n't feed it dry, but soaked.

Professor W. A. Henry, of Wisconsin Agricultural College, reports as follows:

For several reasons the value of cane seed for feed has received little attention. Its importance has not yet impressed itself upon cane growers. As will be seen from Mr. Swensen's report, from one-fifth of an acre of ground, $6\frac{3}{8}$ bushels of seed, weighing 53 pounds per bushel, were obtained, or at the rate of 32 bushels per acre.

The average yield of oats in the vicinity of Madison this season was about 35 bushels.

J. M. Edwards, Oak Hill, Jefferson County, reports 230 bushels of seed, weighing 58 pounds per bushel, from 9 acres.

There is no difficulty in saving the seed, as the heads can lie upon the ground a long time, unless there is an excessive amount of rain. The heads can be drawn and spread on the barn floor, or, what would be better, arranged on racks in a shed like broom corn. Some bind the heads in bundles, and stand them on end in the field, like bundles of wheat, to dry.

During the past few years the manufacture of glucose has grown to immense proportions, and vast quantities of corn (maize) has been used in its production. It will be seen, from the analyses, that sorghum seed contains the same percentage of starch as corn; and its employ-

ment, in place of corn, in the manufacture of starch and glucose, will doubtless tend to maintain its price at approximately that of corn.

Analyses of Bagasses from Sorghum.

The following table gives the analyses of twenty samples of bagasses from nine varieties of sorghum; also, for purpose of comparison, analyses of the juices expressed from the canes.

Excluding the analyses of suckers and leaves as not being comparable with the others, the average result of the proximate analyses is as follows:

AVERAGE COMPOSITION OF EIGHTEEN BAGASSES.

	Per cent.
Ether extract (fats, chlorophyl, etc.)	1 43
Alchohol extract (sugars, salts, etc.)	20 75
Water extract (soluble albumenoids, gum, etc.)	1.48
Insoluble matter (fiber, silica, etc.)	76 34
	100 00
Albumenoids (N. × 6.25)	3 17
Crude fiber	23 19
Sucrose	9 94
Glucose	3 84
Ash	2.77
Water	4 41
Undetermined	52 68
	100.00

The average percentage of juice and bagasse obtained, and the composition of the juice, was as follows:

	Per cent.
Juice expressed	57.61
Bagasse	42.39
Water in bagasse	54 24
Dry bagasse	45 76
Sucrose in juice	12 92
Glucose in juice	1 29
Solids not sugar in juice	2.94
Polarization of juice	12 72

Specific gravity of juice, 1.0726.

ANALYSES OF CANES, JUICES, AND BAGASSES.

Analyses of Canes and Juices.

Date.	Variety.	Per cent of juice.	Specific gravity.	Per cent of glucose.	Per cent of sucrose.	Per cent of solids not sugar.
Sept. 14	New variety (H. S. Coll)	62.27	1 068	1 15	11 79	3.26
14	White Liberian (Nesbit)	60 32	1.072	.93	13.31	3 28
21	New variety (H. S. Coll)	54.09	1 061	1.06	12.18	1 57
21	White Liberian (Nesbit)	62 35	1 074	.98	13.83	2.65
23	New variety (H. S. Coll)	60.15	1.063	1.05	10 79	3 34
23	White Liberian (Nesbit)	56 82	1.068	.88	12 04	3 28
Oct. 3	Suckers from row 2, 3, 4, 5	62 02	1 022	2.04	.66	2 53
3	Leaves from row 2, 3, 4, 5	37.03	1 025	1.40	.27	4.45
10	Neeazana	57 55	1 075	1.75	13 00	3.79
11	Link's Hybrid	61 31	1 074	.69	14.27	2 71
12	White Liberian (Nesbit)	57.89	1.068	.94	11 81	3.07
13	White Liberian (Leaming)	58 86	1.070	72	12.14	3.68
18	do.	49 95	1 068	1.14	12.11	2 77
18	Early Amber	63 61	1 070	1 00	13.18	2.60
18	Link's Hybrid	56 47	1.080	.46	15 41	3.26
30	West India	57.92	1.078	2.04	13.62	2 40
31	Red Sorgho	59.01	1 072	1.27	12 34	3 17
Nov. 1	West India	59 37	1.076	2 04	13 14	2.35
2	do.	59.85	1.074	1.73	12.51	(†)
Dec. 8	New variety (R. Haswell)	39.25	1.095	3 34	15.17	2.61
	Average	57.61	1.0726	1.29	12.92	2.936

Date.	Variety.	Polarization.	Per cent of bagasse.	Weight of fresh bagasse.	Weight of dry bagasse.	Per cent of water in bagasse.	Per cent of dry bagasse.
Sept. 14*	New variety (H. S. Coll)	12 06	37.73	554	257	53 61	46 39
14	White Liberian (Nesbit)	13 60	39.68	472	214	54.66	45.34
21	New variety (H. S. Coll)	11.16	45 91	405	176	56.54	43 46
21	White Liberian (Nesbit)	13 65	37 65	484	238	50.83	49.17
23	New variety (H. S. Coll)	10 61	39 85	309	150	51 46	48 54
23	White Liberian (Nesbit)	12 25	43 18	314	152	51.59	48 41
Oct. 3	Suckers from row 2, 3, 4, 5	1 31	37.98	649	225	65 33	34.67
3	Leaves from row 2, 3, 4, 5	— 98	62 97	546	187	65.75	34.25
10	Neeazana	13 27	42 45	565	262	53 63	46 37
11	Link's Hybrid	14 21	38 69	522	225	56.90	43.10
12	White Liberian (Nesbit)	11 38	42 11	434	205	52.76	47.24
13	White Liberian (Leaming)	12 49	41 14	448	212	52.68	47.32
18	do.	11 81	50 05	552	260	52 93	47 07
18	Early Amber	12 64	36.39	514	233	54.67	45.33
18	Link's Hybrid	15 45	43 53	520	255	50 96	49 04
30	West India	12 93	42 08	478	201	57.95	42 05
31	Red Sorgho	12 71	40 99	483	219	54 66	45.34
Nov. 1	West India	12 57	40 63	448	192	57 14	42 86
2	do.	12 52	40.15	447	191	57.27	42 73
Dec. 8	New variety (R. Haswell)	13 72	60.75	664	292	56 02	43.98
	Average	12.72	42.39	......	......	54.24	45.76

* Inclusive. † Lost.

Analyses of Dried Bagasses.

Date.		Variety.	Ether extract.	Alcohol extract.	Water extract.	Insoluble residue.	Nitrogen multiplied by 6.26.
Sept.	14	New variety (H. S. Coll).	1 84	19.46	1.37	77.33	2.813
	14	White Liberian (Nesbit).	1.25	18 33	1.84	78 58	3 125
	21	New variety (H. S. Coll).	1.20	18 25	1.58	78.97	2 813
	21	White Liberian (Nesbit).	1.72	20 97	1.60	75.71	3.125
	23	New variety (H. S. Coll).	1.07	20 52	1 46	76.95	2 813
	23	White Liberian (Nesbit).	1.17	19 50	1.21	78 12	3 000
Oct.	3	Suckers from row 2, 3, 4, 5.	2 20	11.78	1.08	84 94	5 625
	3	Leaves from row 2, 3, 4, 5.	5 26	12.70	1 17	80 87	13.125
	10	Neeazana.	1 75	23 17	1 34	73 74	3 000
	11	Link's Hybrid.	1 55	23 27	1.55	73.63	3.500
	12	White Liberian (Nesbit).	1 28	17 83	1.79	79 10	3 000
	13	White Liberian (Leaming).	1.57	17 68	.90	79 85	3 125
	18	do.	1 19	22 22	1 71	74 88	4.000
	18	Early Amber	1 55	21 26	1 39	75 80	2 125
	18	Link's Hybrid.	1.43	19 18	1 58	77 81	3 125
	30	West India.	1 52	22 92	1 37	74 19	3 313
	31	Red Sorgho.	1 22	19 51	1.17	78 10	3.125
Nov.	1	West India.	1 85	22 95	2 02	73.18	3 500
	2	do.	1 49	22 17	1 38	74 96	4 000
Dec.	8	New variety (R. Haswell).	1 11	24 34	1 32	73.23	3.500
		Average.	1 43	20 75	1.48	76 35	3.167

Date.		Variety.	Crude fiber.	Glucose.	Sucrose.	Ash in alcohol extract.	Total ash.	Moisture.
Sept.	14	New variety (H. S. Coll).	27 475	3 25	9 75	.84	2 70	4.25
	14	White Liberian (Nesbit)	21 875	4 25	7 10	93	2 60	3 75
	21	New variety (H S. Coll).	21.600	3 25	8 80	.88	2 45	4 00
	21	White Liberian (Nesbit)	21 050	3 75	7.40	1 03	2 95	4.65
	23	New variety (H. S. Coll).	20 775	2 75	10 45	87	3 05	5.20
	23	White Liberian (Nesbit)	21 475	3 75	7.60	1.00	2 80	4 55
Oct.	3	Suckers from row 2, 3, 4, 5.	25 525	2 00	95	1.58	4 10	3 95
	3	Leaves from row 2, 3, 4, 5.	20 250	1 25	.50	1 82	5 90	3.95
	10	Neeazana.	21 100	5 50	10 00	74	3.00	4.40
	11	Link's Hybrid.	23 725	6.75	7 10	1.20	3 00	4 90
	12	White Liberian (Nesbit).	19 975		10 00	.89	2 50	5 15
	13	White Liberian (Leaming).	25 550	3 50	. . .	.94	2 85	3 80
	18	do	22 025	2 75	13 50	1 04	2 70	5.65
	18	Early Amber	22 625	2 50	12 75	.97	2 20	5.00
	18	Link's Hybrid.	23 975	3.00	9 50	.89	2 95	4 30
	30	West India.	24 400	4.50	8 00	.87	2 75	4.65
	31	Red Sorgho.	25 750	3.25	10 50	1 16	2 60	4.20
Nov.	1	West India	23 150	4 25	11.75	1.02	2 95	3.10
	2	do	23 975	4.75	10 25	.77	2 55	4.45
Dec.	8	New variety (R. Haswell).	26.950	3.50	14 50	1 23	3 20	3.35
		Average.	23 192	3 84	9 94	.96	2.77	4 41

LOSS OF SUGAR IN THE BAGASSE.

The most important point established by these analyses is the very considerable loss of sugar, owing to the impossibility for a mill to ex-

press all the juice. We often hear of bagasse as coming from the mill "perfectly dry," but the juice obtained from these canes was much greater in amount (57.61 per cent) than is usually obtained in practice, still the average amount of water remaining in the bagasse was 56.26 per cent; and, if to this we add the alcohol and water extracts of the bagasse, which would naturally constitute the juice, we should have $(20.75+1.48)\times.4576=10.17+56.26=66.43$ per cent of juice still remaining in the bagasses; that is, 64.41 per cent of the weight of the bagasse as it came from the mill.

Surprising as this may appear to those who have not considered it, there can be no doubt but that the above is even short of the truth.

The average amount of juice obtained was 57.61 per cent, and the total sugars in the juices averaged 14.21 per cent, or 8.19 per cent of the weight of stripped cane. The average of the dry bagasses gave 13.78 per cent of total sugars, or 6.31 per cent of total sugars in the fresh bagasses; therefore, the bagasses, as they came from the mill, contained 77.05 per cent as much sugar as was expressed by the mill from the fresh canes.

Since there was 6.31 per cent of total sugars in the fresh bagasses, it follows that the amount of sugars in the bagasse equaled 2.67 per cent of the weight of the stripped cane; also, as the total sugars in the expressed juice was 14.21 per cent, the amount of sugars in the juices equaled 8.19 per cent of the weight of the stripped cane, and therefore the total sugars in the stripped cane was equal to 10.86 per cent of the weight of the cane, and there was lost in the bagasse 24.62 per cent of the total sugars present in the cane.

That this estimate falls short of the truth is obvious when we consider that the juices were analyzed the day they were expressed, while the bagasses in drying had lost much of their sugar through fermentation, as was seen to be true in the analyses of the fresh juices as compared with the analyses of the same juices when dried.

As the water contained in the plant is far more than sufficient to hold in solution all the sugars present, there appears no good reason to doubt that the juice left in the bagasse is identical in its composition with that expressed; but, if we examine the average results of the analyses of juices and bagasses in the table, we find that the per cent of sucrose in the total sugars of the juices was 90.92, while in the bagasses it was 72.13. In certain of the analyses, we find a discrepancy still greater; for example, the analysis of the juice and bagasse of Link's Hybrid gives us in the juice 95.39 per cent of sucrose and 4.61 per cent of glucose in the total sugars, while the analysis of the bagasse

from this cane shows the two sugars to be in this ratio: glucose, 48.74 per cent; sucrose, 51.26 per cent.

Such a result is, beyond question, due to the fact that, during the process of drying the bagasses, there had been an inversion of much of the sucrose, and, in all probability, a loss of glucose by fermentation.

Prof. George H. Cook, director of the New Jersey Agricultural Experimental Station, at New Brunswick, in the report on his work, alludes to the waste in the use of the ordinary mills for extracting the juice, and estimates the loss as being equal to 40 per cent of the sugar present in the cane.

When we consider the magnitude of this industry, this estimated loss assumes immense proportions. Fully $300,000,000 worth of sugar is now annually produced from cane by practically the same methods used in the production of sorghum sugar. According to the estimate of Professor Cook, then, it appears that there is annually lost in the bagasse two-thirds as much, or $200,000,000 worth of sugar. It would appear most desirable that some method be devised by which this enormous waste may be prevented.

Mr. S. Bringier, in a report upon the sugar production of Louisiana, says:

> These considerations give some idea of the enormous losses inflicted upon the sugar interest, and upon the country, by unthrifty methods of production. It is a startling thought, that probably a hundred million pounds of sugar are annually burned up in the bagasse of imperfectly treated canes.

In Ure's Dictionary of Arts, etc., Vol. II, page 758, it says, in reference to this same matter:

> The average quantity of grained sugar obtained from cane juice in our colonial (English) plantations, is probably not more than one-third of the quantity of crystallizable sugar in the juice which they boil.

And the mills do not probably average over 60 per cent of the weight of the cane in juice, or two-thirds of the amount actually present, which would show that but two-ninths of the sugar present in the cane was placed upon the market as sugar.

Another eminent authority states the loss in sugar making as follows:

> Eighteen per cent of sugar in the cane yields not more than 8 per cent of crystallized sugar. The loss is thus accounted for: 90 per cent of juice actually present yields to the mill only 50 to 60; then, in the refining, there is a loss of one-fifth, and of the remainder only two-thirds is saved in boiling, one-third

being lost in molasses; in the bagasse, 6 per cent; in molasses, 3 per cent; in skimmings, 2½ per cent; raw sugar, 6½ per cent.

A De La Cornilliere, in his work on the "Culture of the Sugar-cane and Sugar Manufacture in Louisiana," says:

It is a well-known fact that the cane, after several pressures, even as many as eight or ten, still yields juice, and that a complete exhaustion can only be obtained by dissolving the saccharine substances inclosed in the cellular tissues.

In commenting upon these statements, Mr. Bouchereau, in his report on sugar, says:

The startling facts, so well attested, that 40 per cent of the sugar products of Louisiana, through all her great past, secured in the culture, have been lost through the inadequacy of the machinery employed in manufacture; that nearly one-half the product has been cast away from countless thousands of fields of cane, extending back through so many years, indeed generations; is certainly calculated to arouse the interest, not only of sugar planters, but of society at large, in all its classes and conditions, in the question of sugar production for the future, not here only, but every-where.

A writer in the *Rural New Yorker* says:

From some careful chemical analyses of, and practical experiments with, sorghum-cane growing on the University farm it appears, that, from the proximate analysis of the cane, one acre of sorghum produces 2,559 pounds of cane sugar. Of this amount we obtained 710 pounds, on the farm, of good brown sugar, and 562 pounds were left in the 737 pounds of molasses drained from the sugar. Hence, 62 per cent of the total amount of sugar was lost during the process of manufacture. This shows that the method of manufacture in general use is very imperfect. The 710 pounds of sugar, at 8 cents per pound, would bring $56.80. The molasses is worth, at 25 cents per gallon, $17.75, or the products of an acre of sorghum would bring $75.55. There is no question that, with proper care and apparatus, the above yield can be readily doubled.

In the above it will be observed that there is no allowance made for seed and forage. And he concludes:

Nearly two-thirds of the sugar, as has been said, is left in the bagasse. This could, in great part, be removed by percolation with water, as is done sometimes in the manufacture of beet sugar.

Analyses of Bagasses from Sugar-cane.

The following analyses of bagasses from sugar-cane will show the extent of this loss in sugar:

ANALYSES OF BAGASSES—SUGAR-CANE (PELIGOT).

	First.	Second.
	Per cent.	*Per cent.*
Sugar	7.9	7 8
Molasses	3.0	2 7
Cellulose and salts	38 6	39 5
Water	50.5	50 0
	100.	100.

AVERAGE ANALYSIS OF TWO BAGASSES (DRY)—SUGAR-CANE.

	Per cent.
Sugar	15 86
Other solids	84 14
	100.

The dry cane contained 27.64 per cent of sugar.

The average composition of the four analyses as dry bagasse, would give of—

	Per cent.
Sugar	17.93
Other solids	82 07
	100.

Or, if calculated to fresh bagasse, containing 50 per cent of water, the average would be of the four bagasses:

	Per cent.
Sugar	8.97
Other solids	41 03
Water	50 00
	100.

From the above analyses it will be seen, that bagasse, as it escapes from the mill, contains about 9 per cent of sugar.

EXPERIMENTS IN RECOVERING SUGAR FROM THE BAGASSE.

Some experiments have been made at the Department of Agriculture, with a view to recover from the bagasse the sugar it contained. The apparatus consisted of a series of barrels, so arranged that, having been filled with bagasse, water was allowed to flow in at the top until the barrel was full, and then, by means of a pipe leading from the bottom of the barrel, the water flowed over into a second, and thence to a third barrel, and so on. The overflow from the successive barrels was taken when it first ran off, and the following tables will show the results secured in a large number of experiments:

SPECIFIC GRAVITY OF DIFFUSION JUICES FROM SUCCESSIVE BARRELS.

Number of experiment.	First.	Second.	Third.	Fourth.	Fifth.	Sixth.	Seventh.	Eighth.	Ninth.	Tenth.	Eleventh.	Twelfth.
1.	.....	1017	1025	1030	1034	1036	1037	1038	1040	1044	.	...
2.	1004	1014	1019	1030	1032	1036	1039	1044	1045	1047	1046	1047
3.	1008	1017	1025	1033	1034	1037	1043	1046	1046	1050	...	......
4.	1008	1020	1030	1036	1040	1038	1044	1045	1050	....	.....	.....
5.	1009	1021	1026	1034	1040	1043	1045	1049	1047	....	......	.....
6.	1012	1023	1026	1037	1036	1041	1042	1041	1043	.....	......	......
7.	1005	1014	1022	1030	1032	1036	1039	1040	1044	..	...	.....
8.	1008	1019	1024	1027	1029	1032	1028	1030	1037	....	......	....
9.	1013	1016	1025	1031	1030	1032	1035	1036	1037	....	.....	.....
10.	.	...	...	.	.....	.....	1037	1043	1048	1048	1049	1052
11.	...	....	....	1025	1025	1031	1032	1032	1035	....	......	......
12.	.....	.....	.....	......	1032	1035	1034	1035	1040	.....	.....	......
13.	.....	.....	....	....	1025	1030	1032	1039	1041	....	....	.....
14.	.....	......	.	....	1030	1032	1030	1041	....		......	....
Average....	1.0084	1 0179	1.0247	1.0313	1.0322	1.0353	1.0369	1.0400	1.0425	1.0472	1.0475	1.0495

It will be observed that the increase of specific gravity was very regular, and approximately the same in the several experiments.

The following table gives the analyses of a large number of the juices, which also show close agreement, and give evidence that the operation was performed without any appreciable inversion of the sugar, the ratio of sucrose to glucose in the diffusion juices being quite as good as in the juices expressed by the mill.

These diffusion juices, upon defecation and evaporation, give syrups, in which the relative proportions of sucrose and glucose remained the same as in the juices, and in general they were like the juices obtained by the mill, except in being entirely free from mechanical impurities.

ANALYSES OF JUICES OBTAINED BY DIFFUSION.

No. of Larrels.	First experiment.		Second experiment.		Third experiment.		Fourth experiment.		Fifth experiment.	
	Sucrose.	Glucose.	Sucrose.	Glucose.	Sucrose.	Glucose.	Sucrose.	Glucose.	Sucrose.	Glucose.
1	1 62	1.11	.63	.15	1.13	.30	1.21	.34	1.36	.25
2	2 51	1.25	2.88	.71	2.61	.67	2.99	.63	3 39	.53
3	2.88	2.41	3.94	1.13	3.31	.97	5.24	.94	4.05	.72
4	3.54	2 76	4 54	1.39	4.56	1.36	5.97	1.09	5.64	1 01
5	3.66	2.80	4 83	1 52	4.92	1.44	6.37	1.41	6.27	1 58
6	3.50	2.96	5 02	1.23	5.51	1.27	5.97	1 67	6.11	1.90
7	4.91	1.71	6.18	1 89	6.30	1.54	6.08	2 26	6.40	2 30
8	4.37	3.15	6 32	2 10	6.77	1.75	6.00	2.69	6.28	2 39
9	2.33	3.51	6.11	1.98	5.89	2.03	6.36	2.75	5.62	2 42
10	2.95	3.25	6 90	1.80	7.70	2.09	....	......	....	....
......	....	....	7.46	1.89	....	....	....	....	....	....
......	....	....	7.32	1.78	....	....	....	....	....	....
......	....	....	7.81	1.97	.... .	....	....	....	....	....

Analyses of Juices Obtained by Diffusion—Continued.

No. of barrels.	Sixth experiment.			Seventh experiment.			Average of all.		
	Sucrose.	Glucose.	Solids.	Sucrose.	Glucose.	Solids.	Sucrose.	Glucose.	Solids.
1	1.43	.82	.06	1.22	1.50	.59	1.23	.64	.33
2	1 61	1.92	1.24	1.41	1.78	1.00	2.49	1 07	1 12
3	2.00	2.57	1.35	2.25	2 42	1.35	3.38	1·59	1.35
4	2.41	2.71	1.42	2 87	3.17	1.59	4.22	1.93	1.50
5	2.55	2 98	1.54	2.54	3 04	1 58	4.45	2.11	1.56
6	2.53	3.46	1.74	2 46	3 43	1.97	4.44	2.27	1 86
7	2.40	2 74	1.88	2.96	3.70	2.05	5 03	2.31	1.97
8	2.52	3 31	1.52	....	....	....	5.38	2.57	1.52
9	2.99	3.70	2.02	....	....	....	4.88	2.73	2.02
10	....	....	....	....	....	....	5 85	2.38	....
......	....	....	....	....	....	....	7.46	....	....
......	....	....	....	....	....	....	7 32	....	....
....	....	....	....	....	....	....	7.81	....	....

From the above experiments it will be seen that the water, as it gradually passed through successive barrels of bagasse, increased very regularly in density and in its content of sugar, and after about four barrels of water had passed slowly through the bagasse, the water thereafter passed through without taking up any sugar; that is, the bagasse had been entirely exhausted of its sugar.

It was found, as the average of nine experiments, that it was possible to recover 5.98 per cent of the weight of the bagasse taken in sugars, and that, by these successive leachings, there was obtained ultimately a juice as rich in sugar as was the juice from the mill.

Sugar from Sorghum Bagasse.

RESULTS OF NINE EXPERIMENTS BY COLLIER, IN 1880.

Number.	Pounds bagasse.	Pounds sugar.	Per cent sugar.
1	693	34.17	4.93
2	693	56.81	8.20
3	770	60 92	7.91
4	462	28 48	6.16
5	385	16.36	4.25
6	693	29.68	4.28
7	616	39 97	6.50
8	924	51.81	5 61
9	693	41.20	5.65
			Average 5 98

The bagasses experimented upon were not from good cane, but the leachings were found to compare favorably with the juices expressed from the cane by the mill.

The importance of this matter is such as to justify further experiment in this direction. From the above average results it would ap-

pear, that a per cent of sugar may be recovered from the bagasse nearly equal to that which is expressed in juice even by our best mills.

After this leaching, the bagasse may be used for fuel or for the manufacture of paper pulp, and for this latter use the exhaustion by water increases its value.

Estimate for a Diffusion Leach.

The following estimate is based upon the experiments recorded above, and would suffice for a mill grinding about $2\frac{1}{2}$ tons of cane per hour.

A mill expressing 60 per cent of juice, would furnish 2,000 pounds of bagasse from $2\frac{1}{2}$ tons of cane.

2,000 pounds of bagasse would occupy 125 cubic feet of tank-room, and the tanks filled with bagasse would require 113 cubic feet (848 gallons) of water to fill them.

To take 2,000 pounds of bagasse per hour, would require two tanks, each of $62\frac{1}{2}$ cubic feet capacity, or of the dimensions $3\frac{1}{2} \times 3\frac{1}{2} \times 5$ feet, and would require every hour 848 gallons of water. If the diffusion of the bagasse is completed in three hours, then 6 tanks would be filled before the first would be empty, and 8 tanks in all, with 12 steps on which to place them, would suffice.

ANALYSES OF SORGHUM LEAVES.

In the following table is given the analyses of the leaves of four varieties of sorghum, and of the juices expressed from the stalks from which the leaves were taken. There is in the dried leaves an average of 5.41 per cent of total sugars, while the average amount of total sugars in the juices from the stalks is 14.44 per cent.

As has been shown in another place, there is an increase of about 6 per cent in the amount of syrup, and a decrease of about 6 per cent in the amount of the available sugar obtained when the stalks are passed unstripped through the mill, instead of using stripped stalks.

But it will be seen that these leaves have a composition which shows them to be of very great nutritive value, and, as fodder, they are well worth preserving whenever one strips his cane for the mill. Indeed, their value is such that, if carefully preserved, they would easily repay the cost of stripping.

For purpose of comparison, the following average analysis representing the composition of five samples of hay, are given (A), and the average composition of a large number of American grasses (B), given in the Report of the Department of Agriculture for 1879, pages 112, 123. The average of the four varieties of sorghum leaves is given in (C).

	Ash.	Fat.	N. Free.	Albumen.	Fiber.	Nutr. Ratio.
A	5 36	4.95	52 93	8 78	27.14	1:6 6
B	7 90	2 90	53 90	8.20	27 10	1:6.9
C	10 18	7.06	55.57	13 61	16 54	1:4.1

It appears, then, that the leaves of the sorghums have a higher nutritive ratio than our grasses or hay, and, there is present in them, when dried with care, a large percentage of sugars and albumenoids, two of the most important constituents of animal food.

ANALYSES OF LEAVES OF SORGHUM.

	Per cent juice.	Specific gravity.	Per cent glucose.	Per cent sucrose.	Per cent solids not sugars.	Polarization.	Weight fresh leaves.
African Canes							564
Early Amber	63 61	1070	1.00	13 18	2.60	12 64	432
Link's Hybrid	56 47	1080	.46	15.41	3.26	15 45	396
White Liberian	49.95	1068	1.14	12 11	2.77	11.81	322
Average	56.68	10727	.87	13.57	2 88	13.30	

	Weight dry leaves.	Per cent water in leaves.	Per cent dry matter in leaves.	Fats, chlorophyl. Ether extract.	Sugar and salts. Alcohol extract.	Sol. Alb. Gum, etc. Water extract.	Fiber, silica, etc. Insoluble residue.
African Canes	155	72.52	27 48	6.29	18.67	1 82	73 22
Early Amber	112	74.07	25.93	7 08	21 63	2 51	68 78
Link's Hybrid	117	70 45	29 55	7 48	22 26	2 58	67 68
White Liberian	92	71.43	28 57	7 41	21.48	2 86	68 25
Average		72 12	27 88	7.06	21.01	2 44	69.48

	Nitrogen × 6.25.	Crude fiber.	Glucose.	Sucrose.	Ash in alcohol extract.	Total ash.	Water.
African Canes	14.500	17.475	.50	4.25	2.31	11.25	4 70
Early Amber	13 500	16.475	1.50	3.75	1 23	8 85	4 10
Link's Hybrid	11 375	16 750	2 25	5.00	2 04	8.55	3 55
White Liberian	15.063	15.450	2 00	2.40	1 53	12.05	4.05
Average	13.609	16.538	1.56	3.85	1.78	10.175	4.10

BAGASSE AS FOOD.

By reference to the preceding tables, giving the analyses of the bagasses, it will be seen that their average composition, when dry, is as follows:

	Per cent.
Water	4.41
Crude fiber	23.19
Ash	2 77
Albumenoids	3.17
Carbhydrates	66.46
	100.00

And that of the non-nitrogenous matter, or carbhydrates, 13.78 per cent is sugar.

Or, calculated to the fresh bagasse as it came from the mill:

	Per cent.
Crude fiber	10.61
Ash	1 27
Albumenoids	1.45
Carbhydrates	30.41
Water	56.26
	100.00

And of the carbhydrates 6.30 per cent was sugar.

Now, in accordance with the general method of estimating the relative values of different fodders, we find that these fresh bagasses possess a low nutritive ratio, about 1 to 21.

In Annual Report, Department of Agriculture, 1879, page 57, were given results of two analyses of Honduras and Early Amber bagasses and leaves, made that year, as follows:

	Bagasses.	Leaves.
	Per cent.	*Per cent.*
Crude fiber	19 88	18.25
Ash	3.78	11.79
Albumenoids	3.92	14.79
Non-nitrogenous	72 42	55.17
	100 00	100.00
Nutritive ratio	1: 18.47	1: 4.68

In 1882, as the average of eleven experiments, where many stalks were taken, and of several varieties of sorghum, it was found that the ratio of stripped cane to the leaves was as 5.5 to 1, and as we saw that the relative proportion of stripped cane to the bagasse was as 100 to 42.39, it follows that there would be an average of 23.31 pounds of bagasse to 10 pounds of leaves. The average composition of the mixture of these two in that proportion in which they normally occur can be readily determined as follows:

AVERAGE ANALYSES OF FRESH BAGASSES AND LEAVES.

	Average of 18 bagasses.	Average of 4 leaves.
	Per cent.	*Per cent.*
Crude fiber	10 61	4 61
Ash	1.27	2 84
Albumenoids	1 45	3 79
Carbhydrates	30.41	15.49
Water	56.26	73.27
	100.00	100.00

If we multiply the constituents of the bagasse by 23.31, and add to ten times those of the leaves, and divide by 33.31, we have, as the composition of the mixture of fresh leaves and fresh bagasse, which would be produced from the cane yielding the leaves:

	Per cent.
Crude fiber	8 80
Ash	1.74
Albumenoids	2.15
Carbhydrates	25 93
Water	61.38
	100 00
Nutritive ratio	1:12

The average analyses of 26 specimens of ensilage, published in the Annual Report for 1881–'82, page 572, and of two specimens of maize cut at the period when it would generally be used for the purpose of ensilage, are interesting in this connection, and are as follows:

AVERAGE ANALYSIS OF ENSILAGE AND MAIZE.

	Average of 26 samples ensilage.	Average of 2 samples corn stalks in silk.
	Per cent.	*Per cent.*
Crude fiber	5.99	4.24
Ash	1.33	1.16
Albumenoids	1.37	1.19
Carbhydrates	10.08	10.48
Fat	.79	.57
Water	80.44	82.36
	100 00	100.00
Nutritive ratio	1:7.9	1:9.3

If, now, we assume the following values to the several nutritive constituents of these materials, viz.:

	Cents per lb.
Albumenoids	3.40
Fats	2 93
Carbhydrates	.72

we should have for a ton of 2,000 pounds of each of the above the following values:

MONEY VALUES IN TWO THOUSAND POUNDS.

	Average ensilage.	Maize stalks.	Bagasse and leaves.
Albumenoids	$0 93	$0 81	$1 46
Fats	46	33	62
Carbhydrates	1 45	1 51	3 58
Total	$2 84	$2 65	$5 66

It would appear, then, that this mixture of leaves and bagasse, as it comes from the mill, has a feeding value just twice as great as the average of the 26 specimens of ensilage; and it is, therefore, most desirable that careful and repeated experiments be made for its preservation as fodder, especially in silos. Owing to the disintegration of the stalk, and the rupture of the cells of the plant, the bagasse is in such a condition as to rapidly enter into fermentation, and it would be necessary, therefore, to remove it as speedily as possible from the action of the air by compressing it in silos; owing, also, to this thorough crushing of the hard coating of the cane, the bagasse is in better condition for eating, and the nutritive constituents would the more readily be digested and assimilated.

By general testimony, bagasse is found, when fresh, to be greedily eaten by most stock, and cattle have been known, during the winter, to burrow and eat far into a pile of bagasse, the interior of the heap being obviously in the condition which it would have been if preserved in a silo.

The disposition to be made of the bagasse is, on many accounts, the most important question connected with the sorghum sugar industry.

The sugar of the plant is derived ultimately from the atmosphere, containing, except as an impurity, not a trace of mineral matter. It would be possible, therefore, to produce upon our lands a sugar supply for the world indefinitely without exhausting the soil; indeed, the soil would gradually increase in fertility under cultivation.

But when we consider the remainder of the plant, the seed, the leaves, and the bagasse, we find that for their production large demands are made upon the soil, a demand practically the same as for the production of an equal weight of maize.

If the cane is stripped for the mill, the leaves are either left upon the field or are preserved as food for animals, and with the proper pres-

ervation and use of the manure of the farm, no loss to the fertility of the soil could result from this source.

In regard to the seed, it is most likely that it will be largely consumed upon the farm, especially since its value for feeding stock has been experimentally proved by Professor Cook, of the New Jersey Experimental Station, to be practically the equivalent of maize. Until, therefore, the seed of sorghum shall reach a wholesale price in the market approximately equal to maize, it is more than likely that the farmer will use his sorghum seed as food for his farm animals, and thus secure its consumption upon the farm, returning to his fields most of the mineral matter which the seed has removed in its growth.

There remains only the bagasse and the sediments and scums of the sugar house which could prove any source of exhaustion to the soil. The importance of adding the sediment and scum obtained in defecation to the land directly, or to the manure or compost heap, has already been alluded to. Such disposition of these unsightly products is easy, and would naturally suggest itself to the ordinary farmer.

An experiment made at the Department showed that piling up the bagasse, with the addition of quicklime or solution of potash, caused it during the winter to become thoroughly disintegrated, so that it could easily be added to the land as manure, and by the plow and harrow readily incorporated with the soil.

In those sections where scarcity of fuel exists, the utilization of the bagasse for such purpose is likely to increase, but it is of great importance that the ashes should be carefully saved and applied to the soil, since it is only those constituents of the bagasse, derived from the atmosphere, which would burn or could serve the purpose of fuel.

The mineral matter necessary to the production of a crop of sorghum equal to 11 tons of stripped stalks to the acre would be as follows: 11 tons of stripped cane would give, at 42.39 per cent bagasse, 4.66 tons of bagasse and 6.34 tons of juice. The relative proportion of leaves to stripped cane is about 1 to 5.5, and we should have 2 tons of leaves. A crop of 25 bushels of seed would not be disproportionate to such a yield of cane, which, at 56 pounds to the bushel, would be 1,440 pounds. The average per cent of ash in sorghum juices is about 1.0 per cent (Agricultural Report, 1880, p. 125). We should have, therefore, as the total mineral matter taken from the soil by a crop of 11 tons of stripped cane, the following:

ASH IN A CROP OF 11 TONS OF STRIPPED CANE.

	Pounds.
4.66 tons bagasse, at 1.27 per cent	93.2
6.34 tons juice, at 1 00 per cent.	126 8
2.00 tons leaves, at 2.84 per cent	113 6
1,400 pounds seed, at 1.68 per cent	23 5
Total	357.1

The constituents of the ash from the several portions of the plant is not known, but the analysis of the ash of two samples of the entire cane is given, Agricultural Report, 1880, p. 126, and the analysis of the ash of the seed closely resembles that of maize. If, then, we calculate the amount of these several constituents of the ash upon such basis, we have, in the 357.1 pounds above, as follows:

	Pounds.
Potash	180.8
Soda	.9
Lime	36 9
Magnesia	37.1
Iron oxide	.2
Phosphoric acid	24 2
Sulphuric acid	28.9
Chlorine	28 2
Silica	19.9
	357.1

Loss of Sugar in Drying Sorghum.

The following experiment was made with a bundle of Honduras sorghum, which, when cut, contained from 12 to 14 per cent of sugar in the juice. The cane was dried thoroughly and rapidly in a room where the temperature was about 70° F. Of this dry cane, 502 grams. were taken and cut into thin shavings and beaten in a mortar; 1,300 grams. of water was added, and, after digesting for half an hour, the juice was expressed, amounting to 1,189 grams., or 65.97 per cent of the moistened cane. The juice gave the following analysis:

Specific gravity		1028
Sucrose	Per cent	1.52
Glucose	do.	2.28
Solids not sugar	do.	2.63

It is obvious that the sugar had been almost entirely lost during the drying of the sorghum. Since this cane was dried under circumstances even more favorable than those attending the drying of larger quantities, it is clear that a very large proportion of the nutriment is lost, as in the case of corn fodder or fodder corn dried for food. The preservation of such food in silos would appear commendable, since, in coarser grasses, the large percentage of sugars they contain is, in the longer period required for their drying, almost wholly lost through slow fermentation.

Bagasse as Fuel.

Valuable as we have shown the bagasse to be for the sugar which it contains, the paper pulp which may be produced from it, as a food to be preserved in a silo, or as a source of manure, it is yet true that, to many of our Western farmers, as to the planters of Cuba and other sugar producing regions, it is the cheapest (if not the only available) fuel, and will continue to be used for such purpose, as it has been for years.

In drying the bagasse in the sun, it loses about half its weight, and the dried bagasse is found, from many experiments, to possess about half the value of coal; so that one pound of coal is about equal, in evaporating power, to four pounds of fresh bagasse. A mill giving sixty per cent of juice would then give, for each ton of cane worked, 1,200 pounds juice and 800 pounds of fresh bagasse, equal to 200 pounds of coal. This is ample for the evaporation of the juice, and it is so estimated upon the sugar-cane plantations. The following results, reported by those who have used the bagasse as fuel, with the discussion thereupon at one of the recent conventions of sorghum growers, held at St. Louis, Missouri, will be read with interest in this connection:

The President.—I would like to hear from members on the use of the bagasse, in short, pointed remarks. Who has had success in using bagasse as fuel?

Mr. Clements, of Kansas: We started our works with the expectation of burning coarse fuel—hay, bagasse, or something of that kind for fuel—as we had seen it used on a small scale—and with other fuels, to make up fuel for running the factory. We arranged our boilers and every thing with large furnaces—furnaces seven feet long, grates three feet in length. Back of the grates is the furnace; the draft has all to go in the first three feet. The depth of the furnace, from the boiler grates, is thirty inches. We carry 100 pounds of steam. We found, by drying the bagasse in the sun, giving it one day to dry, it makes better fire than by letting it lay a week in the sun. After it is treated, we stack it up. This season, after we got started, bagasse made all the fuel we could use for evaporation. We started in, and used 100 tons of hay, and the balance of other fuel; and all the fuel we had was used in the hot dry spell about the first of September. From that we started in with bagasse—bought a few tons of hay. When we closed up, we had about 300 tons of bagasse left over. In connection with that, during the wet spell, we had 200 gallons of semi-syrup in the tanks. We obtained coal to finish the syrup. We could not get steam over 70 pounds. I am satisfied that bagasse will make all the fuel that is required to evaporate where steam is economically used.

The President.—What do you have to pay for hay a ton?

Mr. Clements.—A dollar and a half a ton delivered at the factory. A ton of bagasse will make as much steam as a ton and a half of hay, and as much as two tons of straw. I prefer bagasse for fuel to the best wood that could be obtained, delivered at the factory; and it is much better than coal; you can get up steam quicker. With a boiler filled with cold water, you can get steam in thirty minutes, where coal will require an hour and a half.

A Member.—Is your boiler a flue boiler?

Mr. Clements.—Tubular; one is 3¼, the other is 3½; the latter makes steam easier than the other. I think a 4 inch flue is the best size. The less juice you express from the bagasse, the better fuel it makes. It requires a fireman to each boiler. We have a feeder, with a trap door to it; it is very necessary to keep it closed, except when putting fuel in.

Prof. Culbertson, of Nebaska.—I have had a little experience in the bagasse, and coal, and straw business as a fuel; and the experience comes pretty close,

on account of our boiler capacity not being what it ought to be. It was little trouble to get steam enough with good, dry bagasse. When we first commenced we ran with bagasse for fuel, and then we used coal. With the very best firemen we could get, we had 100 to 150 gallons less a day with coal. Bagasse, in that connection, was worth twenty dollars a day to us, over and above what coal would have come to—taking into consideration the decrease in syrup made.

Mr. Clements (in answer to an inquiry).—It would be impossible to keep the necessary fire in a furnace 28 feet long with coal. Where you can have dry bagasse, it is better fuel than you can get from any thing else.

Mr. Stout.—We use bagasse pretty much as Mr. Clements does. We use two fire trains. I have two pans, 33 feet long, with chimneys about 30 feet high. The grates are 4 feet long and 3 feet wide, and probably 2 feet from the pans. We made, on an average, this season, 325 gallons of syrup a day. I am satisfied it would take three cords of wood to have done that much evaporation—probably a little more. We didn't use wood—except about half a cord the day we started up, and at one time when every thing got wet. We came early to the conclusion, after burning bagasse, that, if we could not get that or straw, we would actually shut down. The furnace we arranged for bagasse is so we could not run with coal or wood; it might do with wood split up very fine. I have noticed frequently, in burning bagasse, the blaze came out at the top of the chimneys 30 feet high, and trains, one 28 feet and the other 33 feet long. You have to have the ash pit three or four times as deep (three or four feet), and you have to take it out once a day, when running. If we let it fill up, it will melt the grate in a few hours—if we let the cinders pile up too close to the grate. In this season, the only thing we used was bagasse (except wood, a few hours), and when there came a heavy rain for a day or two, we burned a rick of probably twenty tons of dry straw. We paid a dollar a ton for the straw. A ton of straw, that cost us only a dollar, was worth more than a cord of wood.

A Member.—How did you prevent burning every thing up with the draft; Wouldn't it rain fire all over your premises?

Mr. Stout.—That height of a chimney wouldn't. Several gentlemen have asked whether they could run a small furnace—a small train—with bagasse. We did that, last season, under a Cook pan, 12 feet long, and a chimney 12 or 15 feet high. Out of that chimney it set the bagasse, in the bagasse yard, on fire half a dozen times. That was really dangerous; but with 30-foot flues, this season, the cinders came out—but it is so high before they light, I think they go out. They are very dangerous in small works, with chimneys only 10 or 15 feet high.

A Member.—My chimney was 30 feet high, and my building was set on fire.

A Member.—Can you burn bagasse that you grind this morning, the same day?

Mr. Stout.—If it is a dry day, we can burn bagasse after two o'clock. You can burn it all that evening and all that night; bagasse that we scatter in the morning.

A Member.—Can you keep it a year, and then burn it?

Mr. Stout.—Yes.

A Member.—Suppose you had all wood, would you use bagasse then?

Mr. Stout.—I think I should; I don't think it would cost as much to use the bagasse as to cut the wood.

A Member.—I would like to ask Mr. Stout if he does not think a spark-arrester could be used on the smoke-stack, to avoid fire?

Mr. Stout.—I have no doubt they can. I tried a bonnet; it stopped the draft so we had to take it off. Railroads do that, and I have no doubt it can be fixed, and don't think there is much danger with 30-inch flues.

A Member.—Is there any advantage in a crooked grate?

Mr. Stout.—Yes; I think that it is an advantage. I think the grate should crook down.

A Member.—What size of opening in the grate?

Mr. Stout.—Not very particular; I think about two inches.

Mr. Clements.—I find a set of grates will last longer with begasse than with coal or wood, if the fireman attends to his business. I think the distance between the grate part depends a great deal on the fineness with which you crush the cane.

Mr. Frazer.—How far from the front end do you put the feed-tube?

Mr. Clements.—On a furnace five feet long, put it a foot from the end.

Dr. Mayberry, of Kansas.—I live in a part of the country where we are almost destitute of fuel, except coal, and coal is high—$6.50 a ton. The first two years I ran, I ran on coal oil; it cost five cents net a gallon; that was cash. I have tried three different kinds of coal, and there is nothing makes steam for me like bagasse does. In feeding bagasse in the furnace, I want it as loose as I can get it. I crowd the furnace, and then take a long iron bar and make it loose. I have one trouble with my factory. I have not enough boiler. I can run better on bagasse than on any kind of coal. If coal was lying in piles free of charge, I would n't use it. I dont think that bagasse can be made into any thing that will pay as well as fuel. I have had a good many fires from a smoke-stack forty-six feet to the top. I think a good draft is essential.

Mr. Hoyt said he had a cut of Squier's bagasse furnace, which he passed around the audience, there being no patent on it. It has an arch in front of the pan to build the fire in, and the flame is thrown up by it against the pan. I can make a hotter fire with bagasse than with any thing else, except chemicals. A fork full will burn in 5 or 6 minutes.

The following plate, No. XLVII, represents the bagasse furnace, invented by Isaac A. Hedges, and now manufactured by J. A. Field & Co., of St. Louis, Missouri.

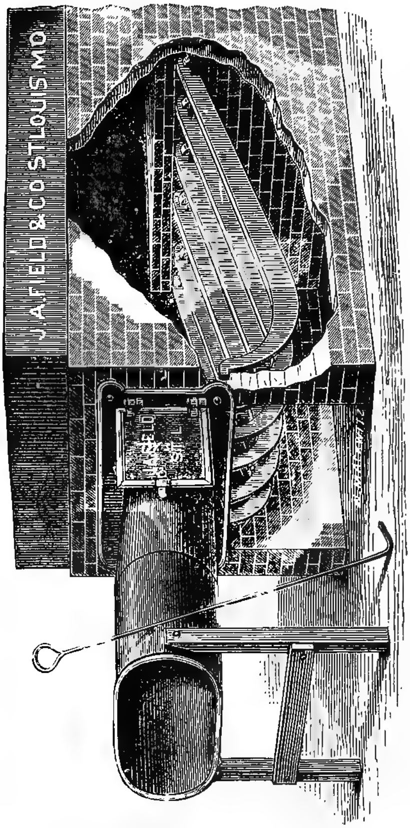


Plate XLVII.

BAGASSE FURNACE.

No. 1. Complete for Furnace, 2 fet wide, grates 3 feet long.
No. 2. Complete, 3 feet wide, 4 feet long.

Paper Pulp from Bagasse.

From the analyses of 18 bagasses, it will be seen that the average juice expressed from the canes was:

	Per cent.
Juice	57.61
Bagasse	42.39
	100.00

The average of crude fiber was 10.61 per cent of the fresh bagasses, or 4.50 per cent of the stripped stalks, so that each ton of stripped stalks contained 90 pounds of crude fiber.

A sample of pulp made from the bagasse of sorghum was submitted for examination to one of the largest paper-makers of the United States, and was by him said to be worth $4\frac{1}{2}$ cents per pound.

This bagasse was treated by the ordinary processes for making paper pulp. An average yield of ten tons of stripped cane to the acre would give 900 pounds of pulp, which, at the above price, would amount to

$40.50. It appears that this material could be thus economically used, and so be another source of profit in the cultivation of sorghum.

SCUM AND SEDIMENT FROM DEFECATION.

The following analyses show the average composition of several samples of scum and sediments from the defecation of sorghum juices:

ANALYSES OF SEDIMENT AND SCUM OF SORGHUM IN SUGAR MAKING.

	Sediment.	Scum.
	Per cent.	*Per cent.*
Ether extract, wax, fat, chlorophyl, etc.	16.28	9 53
Alcohol extracts, sugars, resins, etc.	8.06	27 00
Water extract, gum, etc.	33.81	38 83
Insoluble in ether, alcohol, and water	40.86	23.98
	99 01	99 34
Ash, per cent	19.49	13 07
Potash (K^2O)	12.36	19.81
Soda (Na^2O)	3 87	6.03
Lime (CaO)	32 13	26.43
Magnesia (MgO)	2.42	1.92
Sulphuric acid (SO^3)	1.04	2.62
Chlorine (Cl)	2.34	6.02
Phosphoric acid (P^2O^5)	6.18	2 39
Silica	27 81	23 40
Sand, etc.	10.01	10.93
	98 16	99.55
Nitrogen, per cent	2.55	1.46

The following analyses of two different specimens of sediments and one of skimmings, show the great variation in these, due, doubtless, to the mechanical conditions prevailing in each defecation:

	Liberian lime precipitate.	Honduras lime precipitate.	Honduras skimmings.
Moisture	9.77	7.69	5.72
Ash	21.69	7 00	14 30
Chlorophyl and wax	17.60	8.95	14.44
Sugars	10 80	43 96	15.06
Resins and trace albumen	3 61	3 26	5.08
Gum	6.02	11 40	11.10
Albumenoids	22.58	4.55	8.05
Humus-like substances, difference	5.73	12.71	5 58
Crude fiber	2 20	48	5 49
Starch isomers	Trace.	Trace.	15.18
	100.00	100.00	100.00

The large amount of ash in Liberian lime precipitate and Honduras skimmings is due to the presence of considerable clay, which had been used to hasten the clarification of the juice. There was little or no clay present in Honduras lime precipitate. The claying seems mechanically to have carried down a large proportion of the albumen in the Liberian lime precipitate.

The large percentage of nitrogenous matter, sugars, and ash, especially potash, in each of the above analyses, is evidence of the great value of these waste products, and great care should be taken that they be utilized, if not as food for swine, at least as a fertilizer to be added to the compost heap, the manure pile, or to the land directly.

Many farmers have used them as feeding material with excellent results, as the following testimony shows:

All my scum I feed to cows and hogs. I find that by the use of the scum my cows will give a double yield of milk; and, for my part, I would rather have milk than vinegar. As an article of commerce, vinegar has rather a dull sale with us. I find the scum makes excellent hog feed.

Mr Powell, of Wisconsin.—I would like to ask if Mr. Stebbins kept any account of his hogs and cows, by which he could give the results in dollars and cents.

Mr. Stebbins.—I could not definitely; I take my hired man's word for the amount of milk given by the cows. He told me they gave about double the amount of milk they did before he commenced feeding scums; and, as regards the hogs, I know they did right well when they had nothing but scum. I did n't raise hogs before I commenced my mill, and I could not give any figures. I am well satisfied with the working of the field.

Mr. Powell.—Shoats and hogs will do splendidly from the skimmings; they will do remarkably well if you will only mix the skimmings with shorts.

Mr. Folger.—I tried an experiment of that kind with twelve hogs, averaging 125 lbs.; I fed them three weeks with skimmings, and the result was 50 lbs. to the hog in that three weeks—600 lbs. difference in the weight; they averaged 175 lbs. at the close of the three weeks. On Sundays they were fed corn; the rest of the time merely skimmings, and nothing else.

Prof. Culbertson, of Nebraska.—Last year from the skimmings of eighteen hundred gallons, and the seed from six acres of cane, the hogs weighed 2,000 lbs. more at the end of the season; there were about thirty-five, and confined to that exclusively.

Dr. Mayberry.—My pigs got nothing else than skimmings; I have thrown them a little cane seed occasionally; and I have as fine hogs as are grown in that section of country. I have heard men say they could see themselves on them. I would rather have cane seed than corn for feeding them.

Prof. Henry.—I want to speak of the value of the skimmings. I have found that, when fed to pigs, all they will eat, it gives them a very fair growth. I hope a majority of our farmers will be able to report at our next convention how skimmings work for feed. The value of the skimmings is probably from

half to two-thirds that of skimmed milk, and you are throwing away, at your works, from three to ten barrels a day of it. By using skimmings you would be able to carry your hogs from a month to six weeks without giving them any corn at all. I made this fall a pound of pork from eight pounds of meal, and that was the result in Philadelphia, with nothing but skimmings mixed with warm water.

The President.—A friend in Pennsylvania said he had his fed to his milch-cow. I never tried it, but I have it from a brother of Seth H. Kenney, who has always worked with him, although I had the opinion that if skimmings were fed to a milch-cow it would dry her up very quickly, but I was assured by him that his cows almost doubled their milk as soon as the mill commenced running and they were fed on skimmings. I would feed it to hogs, and all they wanted of it. I did one year, and my shoats did splendidly, and my large fatting hogs did nicely too. It made them fatten very fast. Do not give skimmings to the hogs after it has fermented, give it fresh from the mill, or it will be a damage, and not a benefit.

Henry Linley.—I can fully indorse what the president said about feeding it to hogs. I have fed my green skimmings a number of years, and I should say we should not give it to them after it has fermented. I have had pigs as drunk as could be. I generally give it to them as soon as I can, and the trouble is, I can not get half enough. The hogs prefer skimmings to milk.

Vinegar from Skimmings.

The manufacture of vinegar from the skimmings and sediments of defecator, evaporator, and settling tanks, has been by many rendered a source of profit.

It is necessary that the clear liquor be drawn off from the tank containing these waste products before the acetic fermentation begins; since otherwise the acetic acid formed will unite with the lime of the sediment, and destroy the vinegar. After drawing off the clear liquor into barrels, or a fermenting tank, the remaining sediment may be used as a fertilizer. The addition of wash waters to the contents of the scum and sediment tank will sufficiently dilute them to render their content of sugar easily removed.

It will be found cleaner to use the scum and sediments as food for swine, and reserve in a separate tank the skimmings of the evaporator, sweet water from washings, etc.

The following testimony from those who have made vinegar will be of interest:

Mr. Powell, of Wisconsin, Mississippi Valley Cane Growers' Association.—I must say a little for my vinegar. I take the settlings and skimmings and run them right outside my mill. I have a large building, 42 x 85, two stories high. I run them outside in a large tank. I have six large tanks, holding three thousand gallons each, that I use for the storage of syrup and vinegar. A great many have wanted to know what process was used to make vinegar. Sim-

ply to settle off the thick substance from these skimmings, running the clear juice into the tanks from the outside inside, and keeping it a time—one year. I want to make good vinegar.

The President.—How do you reduce that, with water?

Mr. Powell.—Don't reduce it at all; just about as it comes from the mill, settlings and skimmings, just let it stand till it works itself down to vinegar. I pump mine up and filter it through straw filters to take out any little particles. I have noticed some receipts in the papers; men want to go through a great ceremony; I think that is all wrong.

The President.—How many gallons of vinegar do you make off sixty acres?

Mr. Powell.—In making 7,268 gallons of syrup I made 6,000 of vinegar. Those 6,000 gallons of vinegar needed no expense nor labor, except to provide yourself with tanks; the tanks will probably be forty-five to fifty dollars apiece. With the exception of a little attention, while doing your other work, you need not take time specially for this, only to see that in transferring from one tank to the other you take out the impurities. I have had some covering put over the tanks, matched flooring, and those tanks have not frozen only so that I can take a pencil and work it right round the little slush of ice on the top. The mercury indicated 30° below zero before I left home.

A Member.—Do you sell the vinegar for manufactured cane vinegar?

Mr. Powell.—I sell it for pure manufactured cane vinegar.

The President.—How does it compare with other vinegar in price?

Mr. Powell.—As far as price is concerned, I asked, until quite recently, twenty cents a gallon by the barrel. I found it accumulated on my hands, and I put it at sixteen. But I have something that is better for me in the locality where I live. I have 10,000 gallons of better vinegar than you can buy in the city of Chicago. Three years ago I ordered from a large factory in Faribault six large storage tanks, capable of holding about 2,600 gallons each. I am using four of these to run my skimmings into. There is a class of skimmings I do not allow to go there, but that that I think is fit I run there, and there I let it stand till I get through with my other work; and, if it is too late to filter it, then I let it stand till next spring. Then I filter it, open the windows and doors for free circulation of air, and you will have better vinegar than you can buy, I believe. I do not add any water to it. I filter it through a couple of barrels of straw. I believe in simplicity. These highfangled notions, that cost a great deal of money, I am going to repudiate till I know something about them. The barrels are placed one on top of the other, and the juice pumped up and allowed to run through them. There is not a particle of any thing in the 10,000 gallons but the skimmings; but, in an experimental way, I have taken a gallon or so and dusted in a little sulphur, and I find that it clears it a little. The sample exhibited here was nothing of the kind, however. It was drawn out of a tank containing 2,500 gallons. It commences to ferment in the tank very soon. It freezes in the winter, but that does not hurt it a particle. I do not put the green skimmings into it. I run the green skimmings outside, and they are settled till they will run comparatively clear into the tank, and the other is drawn off.

SORGHUM AS FODDER.

It will interest many to learn the value of sorghum for fodder, and the analyses below will show how it compares with maize for such purpose. Experiments have been made in substituting it for maize in the silo, with excellent results, as by its analysis we should expect.

Below are given the results of the examination of the stalks of Egyptian sugar corn, Honduras, and Early Amber sorghums, and the leaves from the same. This examination was made for the purpose of determining the loss of sugar in the method employed in its extraction; also to determine the relative nutritive value of the leaves and stalks, pressed and unpressed. The stalks selected were split lengthwise, so that a fair average might be taken, and one-half was dried thoroughly without pressing, and the other half was passed through the mill, and the bagasse, or pressed stalks, carefully saved and dried.

LEAVES, STALKS, AND BAGASSE, FROM CORN AND SORGHUMS.

	Weight fresh.	Weight bagasse.	Weight juice.	Per cent juice.	Weight dry.	Per cent water.
Egyptian sugar corn, leaves	380	.....	.....	.....	116.6	67.3
Egyptian sugar corn, one half of 4 stripped stalks, unpressed	832	.....	.....	.....	126 0	84.9
Egyptian sugar corn, one half of 4 stripped stalks, pressed	875	460	415	47.43	99.0	88.7
Honduras sorghum, leaves	432	.....	.....	.....	100.8	76.7
Honduras sorghum, one-half of 2 stripped stalks, unpressed	1,428	.....	.....	.....	285 3	80.0
Honduras sorgum, one-half of 2 stripped stalks, pressed	1,390	724	666	47 91	222 7	84 0
Early Amber sorghum, leaves	399	.....	.....	.....	99.7	75 0
Early Amber sorghum, one-half of 3 stripped stalks, unpressed	651	.....	.....	.....	157.9	75 7
Early Amber sorghum, one-half of 3 stripped stalks, pressed	905	458	447	49 39	147 8	83.7

A determination of the proximate constituents of the dried leaves, stalks, and bagasse, is given below, from which it will appear that there still remains a large amount of sugar in the bagasse, which the process employed failed to remove from the stalks; also that the per cent of starch compounds is greater in the pressed than in the unpressed stalks, and that the percentage of nitrogenous matter remains nearly the same. The nutritive value of the pressed stalks is nearly, if not quite, equal to that of the unpressed stalks, weight for weight.

PROXIMATE ANALYSES OF STALKS, BAGASSE, AND LEAVES OF SWEET CORN AND SORGHUM, CALCULATED TO THE DRY SUBSTANCE.

	Unpressed stalks, Early Amber sorghum.	Unpressed stalks, Honduras sorghum.	Unpressed stalks, Egyptian sugar-corn.	Bagasse of Early Amber sorghum.	Bagasse of Honduras sorghum.	Bagasse of Egyptian sugar corn.	Leaves of Early Amber sorghum.	Leaves of Honduras sorghum.	Leaves of Egyptian sugar corn.
Organic acid, chlorophyl, color.	7 36	5.39	2.85	1 47	2 01	1.11	1 46	3 29	1.48
Wax	.94	.33	.44	.35	81	40	5 05	1.67	.54
Brown resin	6.98	6 00	8 11	5.11	3 53	5 75	7 91	6 67	5 20
Sugar	34 73	38 14	26 01	19 36	21 77	10.08	8 58	9.37	8 21
Gum.	2 14	1 57	1 38	2 04	2 20	1 33	3 82	2 78	4 54
Starch isomers	20 34	17 67	22 44	31.46	26 27	23 16	14 49	21.22	24 77
Albumenoids	4.95	4 81	6 90	3 96	3 87	6.04	13 14	10 43	11 34
Alkali extract, by difference	. .	5 15	6 09	13 35	15 10	22 26	12 08	11.98	12 65
Crude fiber	16 01	16.48	19.82	19 10	20 66	25 00	17 98	18.51	20 83
Ash, by ignition	6 55	4 46	5 96	3 80	3 75	4 87	15 49	14 08	10 44
	100 00	100 00	100.00	100 00	100 00	100 00	100 00	100.00	100 00

The amount of sugar in the Early Amber cane, dry, is to the amount present in Early Amber bagasse, dry, as 100 is to 55.74.

In Honduras cane, dry : Honduras bagasse, dry : : 100 : 57.08.

In Egyptian sugar corn, dry . Egyptian sugar corn bagasse, dry : : 100 : 38.75.

As will be seen from these analyses :

	Per cent sugar.
The Honduras cane, fresh, contained	7.62
The Early Amber cane, fresh, contained	8.42
The Egyptian sugar corn, fresh, contained	3.94

While the sugar remaining in the bagasse, calculated to the fresh cane which produced these bagasses, gave as follows :

	Per cent sugar.
Honduras sorghum	1 82
Early Amber sorghum	1.60
Egyptian sugar corn	.60

In other words, it will appear that there was occasioned a loss of—

23 8 per cent of the sugar present in Honduras sorghum.
18 9 per cent of the sugar present in Early Amber sorghum.
15.2 per cent of the sugar present in Egyptian sugar corn.

The following testimony as to the value of sorghum for fodder has been gathered. For this alone, the plant appears to be one of the most valuable agricultural products :

At the Kansas Wool Growers' meeting, Mr. Wadsworth said he had 4,500 sheep feeding in one plain, and 2,300 in another, during the winter. He had about 350 acres of sorghum. He thought 50 acres of sorghum, drilling in about one peck to the acre, being careful not

to get it too thick, and cutting up half to feed in stormy weather, would feed about 1,000 sheep through the winter. He used Early Amber and Orange. Former the sweetest, but shelled out more.

John D. White, Tulip, Dallas county, Arkansas, Report of Department of Agriculture, 1857, page 197, says of stalks of sorghum:

> After even heavy frosts, stock still eat it with evident relish. Cattle, sheep, and horses, are fond of the cane, which possesses excellent fattening properties. Hogs, also, will eat it voraciously, even after it has been crushed.

Ample time for two crops for forage.

Mr. N. C. Merrill, Clorinda, Ness county, Kansas, says he, for four years, used sorghum as a substitute for corn for feeding stock, with extremely satisfactory results.

Begin to feed as soon as sorghum is two feet high, and by the time it heads out, hogs and cattle will begin to take on flesh very fast. When lower part of head is ripe, cut with mowing machine with rake attachments, and put in shocks. Cost, $1.25 to $2 per acre to put it into shocks. From 500 to 800 pounds of beef (live weight) can be realized from an acre, in September, October, and November, using no other feed whatever. I realized at the rate of 1,100 pounds pork from an acre in September and 700 pounds in November. Hogs fatten very fast from July to September; and from December to spring, with little range, will keep in good growing condition. The larger the stalks, the better for hogs. Sorghum is really our best corn in this part of the State.

CHAPTER XII.

(*a.*) Statistics of production of sorghum in the United States.
(*b.*) Production of sugar from sorghum.
(*c.*) Sorghum compared with other leading crops of United States.
(*d.*) Marketing of syrups.
(*e.*) Central factories.

PRODUCTION AND PROFITS OF SORGHUM CULTIVATION.

The Department of Agriculture received the following returns, as to the crop of 1882, from the several states:

State.	Number of counties.	Number of gallons syrup.	Pounds of sugar.
Arkansas	24	729,500	
Alabama	12	520,125	
Dakota	5	139,648	
Georgia	42	568,023	5,150
Indiana	35	618,410	
Illinois	32	660,633	13,200
Iowa	[illegible]	491,949	731
Kansas	32	950,947	100
Kentucky	35	853,700	
Louisiana	10	81,800	
Missouri	37	1,408,350	2,400
Minnesota	22	267,483	100
Michigan	16	.46,503	
Mississippi	15	530,100	2,200
Maryland	1	1,200	
New Jersey	2	42,000	319,000
New York	8	101,261	90,150
Nebraska	19	177,420	60,000
North Carolina	20	371,300	1,500
Ohio	19	201,555	275
Pennsylvania	1	1,200	
South Carolina	6	292,500	
Tennessee	31	2,122,700	50
Texas	47	958,940	800
Utah	7	67,480	10,000
Virginia	20	132,871	
West Virginia	13	379.200	125
Wisconsin	14	281,300	5,000
28 States	563	12,998,098	510,781

This is but a small number of the counties in the states enumerated, and undoubtedly some of the best sugar-producing counties have been omitted.

The census of 1880 thus far contains accurate statistics from only four states, viz:

States.	Acres.	Sugar.	Molasses.
		Pounds.	*Gallons.*
Kansas	20,643	18,060	1,414,404
Louisiana	1,015	4,000	38,736
Minnesota	5,221	3,457	345,556
South Carolina	7,660	8,225	276,046

The above amount of syrup, which is confessedly far below the aggregate produced,* is equivalent to one hundred million pounds of sugar, which is five per cent of our sugar supply, thus showing conclusively how extensive this industry has become within the past few years.

It is to be remembered that, at present, the demand for good syrup is so great, and the prices so remunerative, that many of the largest manufacturers have aimed solely at the production of syrup. Indeed, it is a not unusual inquiry on the part of manufacturers, "how they may prevent their syrups from crystallizing," showing, conclusively, that there is no trouble in obtaining sugar from the sorghum juices.

The statistician of the Department of Agriculture reports as follows, as to the production of sorghum in the United States:

It will be seen great, fluctuations in area have occurred, that the greatest extent of cultivation in the older states was during the war period, and that a decline followed, except in newer states rapidly advancing in settlement.

There is scarcely any record of sugar, except in Ohio, where the product was greatest prior to 1870.

In the more western states, there has been a revival of interest and extension of cultivation since the introduction of the Early Amber variety, from which some sugar has been made.

In 1860 and 1870 the census presented production as follows:

	1870.	1860.
	Gallons of syrup.	*Gallons of syrup.*
Indiana	2,026,212	881,049
Ohio	2,023,427	779,076
Illinois	1,960,473	806,589
Kentucky	1,740,453	356,705
Missouri	1,730,171	796,111
Tennessee	1,254,701	706,663
Iowa	1,218,636	1,211,512
Product of the above states	11,954,073	5,537,705
Product of other states	4,096,016	1,211,418
Product of the United States	16,050,089	6,749,123

* A more carefully ascertained return from Wisconsin, according to Prof. Henry, gives, as the production of syrup in that state, 385,668 gallons, instead of 281,300; and the production of syrup in Kansas, in 1882, is estimated as being about 2,250,000 gallons, instead of 950,947, and an acreage of over 90,000.

The returns of sorghum in the recent census have not been tabulated, except in two or three states. Only South Carolina and Kansas are complete, as follows:

	1880.			1870.
	Acres.	*Pounds sugar.*	*Gallons molasses*	*Gallons molasses.*
South Carolina	7,660	8,225	276,046	183,585
Kansas	25,643	18,060	1,414,404	449,409

The following states, in which the interest has been and is most prominent, are thus represented by local official enumerations:

OHIO.

Years.	Acres.	Sugar.	Syrup.
		Pounds.	*Gallons*
1862	30,872	27,486	2,696,159
1863	31,255	27,359	2,347,578
1864	29,392	41,660	2,609,728
1865	37,042	56,066	4,003,754
1866	43,101	46 951	4,629,570
1867	17,804	20,094	1,255,807
1868	25,257	28,668	2,004,055
1869	22,231	27,048	1,683,042
1870	23,450	21,988	2,187,673
1871	23,072	25,505	1,817,042
1872	12,932	34,599	968,130
1873	9,426	36,846	692,314
1874	12,108	36,410	941,510
1875	13,144	21,768	928,106
1876	15,929¾	25,074	1,185,235
1877	16,104¾	7,507¼	1,180,255
1878	16,305	11,909	1,273,048

MINNESOTA.

(No official returns of sugar.)

Years.	Acres.	Syrup.
		Gallons.
1868	....	81,375
1869	629	31,191
1870	728	56,370
1871	1,244	73,425
1772	859	78,095
1873	747	53,226
1874	1,146	69,599
1875	1,534	70,479
1876	1,695	72,489
1877	2,200	140,153
1878	3,207	329,660
1879	5,033	446,946
1880	7,317	....

IOWA.

Years.	Acres.	Syrup.	Sugar.
		Gallons.	*Pounds.*
1858	5,606	410,776	......
1862	......	..	21,496
1865	21,452	1,443,605	8,386
1867	25,796	2,094,557	14,697
1869	26,243	2,592,393	....
1875	15,768	1,386,908	....

ILLINOIS.

(No official returns of sugar.)

Years.	Acres.	Syrup.
		Gallons.
1879	17,883	1,309,400
1880	9,825	636,216

KANSAS.

Years.	Acres.	Syrup.	Sugar.
		Gallons.	*Pounds.*
1872	......	....	....
1873	......	....	..
1874	14,103	......	540,338
1875	23,026	....	1,149,030
1876	15,714	.	839,147
1877	20,784	2,390,131	1,195,066
1878	20,292	2,333,566	1,166,783
1879	23,665	.	1,224,557
1880	....	1,429,476	......

For twenty-five years past, the average yield of syrup, varying from 16,000,000 gallons per annum to 5,000,000 or 6,000 000, has probably averaged about 11,000,000 gallons, valued at 65 cents to 40 cents. For syrup, fodder, and all purposes, the average value of the crop may have approximated $8,000,000 per annum.

Mr. J. A. Field, of St. Louis, Mo., in December, 1882, sent out several hundred circulars of inquiry as to the cultivation and manufacture of sorghum, and received replies from the following states, viz.: Vermont, New York, Pennsylvania, New Jersey, Virginia, North Carolina, West Virginia, Tennessee, Alabama, Georgia, Louisiana, Ohio, Indiana, Illinois, Wisconsin, Minnesota, Dakota, Iowa, Nebraska, Kansas, Missouri, Texas, and two provinces, viz., Quebec and Ontario, Canada: in all, 21 states, 1 territory, and 2 provinces.

All our reports are for the manufacture of syrup. We have, therefore, no information pertaining to the granulation of sugar from these sources.

The number of acres grown by the parties making these reports was 639, with an additional amount, worked upon shares, grown by other parties, of about 900 acres, making a total of 1,539 acres. The number of gallons of syrup produced from the 639 acres was 54,245, to which must be added the product of that worked on shares, equal to 76,100 gallons, making a grand total of 130,845 gallons.

The average number of gallons per acre was $87\frac{4}{10}$. The average price of syrup was $54\frac{1}{2}$ cents per gallon, making the value of an acre $47.76. The average cost of cultivation, harvesting, and manufacturing, was reported at 15 cents per gallon, making a total cost of $13.10 per acre, leaving a net profit of $34.66. If we add to this the average product of seed, of 30 bushels per acre, sold at 35 cents per bushel, or $10.50, we have a total net profit of $45.16 per acre.

The lowest number of gallons per acre was 26. This was grown on sod ground in Kansas. On the same farm, and nearly adjoining it, was another lot, planted on old ground and properly cultivated, which yielded 200 gallons per acre. This contrast proves that the proper preparation of soil and cultivation of crop materially advance the product in this, as well as any other crop. The highest number of gallons per acre was grown from Early Orange, in Southern Illinois, producing 360 gallons per acre.

A large number of the parties making these reports were new beginners. This accounts partially for the small quantity produced per acre. Others report a wet, cold, backward spring, followed by severe drought, as the cause of shortness of the crop.

All the parties speak in the most encouraging manner as to their faith in the profitableness of the crop.

Professor Henry, of the State Agricultural College, Madison, Wisconsin, reports as follows as to certain sorghum growers in that state:

S. Hanson, of Whitewater, one of the oldest and most experienced growers in the state, reports 18 gallons from 10 rods of ground and 200 gallons per acre from larger pieces.

Joseph H. Osborn, Oshkosh, reports the highest yield 226 gallons, with an average of 150.

N. D. Comstock, Arcadia, Trempealeau county, estimates the average at 125 gallons.

Maxon and Almony, Milton Junction, Rock county, estimates the average at 150 gallons.

J. H. Rhodes, Sextonville, Richland county, raised on 1 acre 170 gallons.

O. S. Powell, of River Falls, Pierce county, estimates the average crop at 100 gallons.

H. T. Webster, Keene, Portage county, obtained 40 gallons from 28 rods of ground.

J. D. Sherwood, Dartford, Green Lake county, reports one-third of an acre yielding 12,588 pounds of stalks, from which 79.14 gallons of syrup were made.

A. J. Decker, Fond du Lac, considers 125 gallons the average.

Mr. S. Nason, of Nasonville, Wood county, where cane was grown this season for the first time, reports 800 gallons from 4 acres.

Evan Erickson, Stévenstown, La Crosse county, obtained 1,050 gallons from 5 acres.

The average yield of syrup on good ground, in a favorable season, may be

set down at about 160 gallons. With such culture as is usually given to it, the yield will be about 100. It may be set down as a fact that, wherever it has been planted in the state, it has succeeded, no matter how poor the soil was. It promises to be one of the very best crops for our sandy lands, for, though the yield per acre will not be large, the syrup will be of fine quality. Land on the experimental farm, which produced 50 bushels of corn per acre, this year gave 200 gallons of thick syrup.

The following tables give details as to the crop, the products, cost of cultivation, and profits, from several cultivators and manufacturers, and the accuracy of most of them have been established by affidavits:

	Ill., Ind., Univ., Champaign, 1882.	State Ag. Coll., Madison, Wis., 1882.	John G. Clark, Wis., 1882.	Paul Steck, San Francisco, Cal., 1882.	Nelson Maltby, Geneva, Ohio, 1882.	Drummond Brothers, Warrenburg, Mo., 1882.
No. of acres of cane grown	185 8	3.6	12 5	240	17.5	26 5
Tons stripped cane	1724	37.6	151	3600	167 5	243
Tons stripped cane per acre	9 28	10.44	12 1	15	9 57	9 17
Pounds of sugar made	86,603	2847	9600	10,000	4380	1464
Gallons of molasses made	25,137	315	1450	54,000	2561	3930
Pounds of sugar per ton of cane	50.3	75.7	63 6	80-90	62	50
Gallons of molasses per ton of cane	14 6	8 4	9.7	15	15 3	16 2
Pounds of sugar per acre	466	791	768	42	593	55
Gallons of molasses per acre	135 3	87.5	116	225	146	148
Total value of product, dollars	8618	385	1396	27,000	1412	1965
Total cost of product, dollars	5678	....	653 43	24,400	....	611
Total profits, dollars	29.40	....	742 57	2600	....	1354
Value product per acre, dollars	46 38	107 00	111 86	112 50	80 70	74.15
Cost product per acre, dollars	30 56	....	52.40	101 67	....	23 07
Profits product per acre, dollars	15 82	....	59 46	10 83	....	51.08
Total value product per ton cane, dol.	5 00	10 24	9 25	7.50	8.43	8 08
Profits per ton of cane, dollars	1.71	....	4.91	.72	....	5 57
Seed per acre, bushels	....	21 1	....	....	28.5	15
Syrup sold for per gallon	....	....	40	50	....	50

	A. J. Decker, Fon du Lac, Wis., 1882.	Wm. Frazier, Esofea, Wis., 1882.	Jefferson Sugar Co., Jefferson, O., 1882.	Oak Hill Co., Edwardsville, Ill., 1882.	Clinton Bozarth, Cedar Falls, Iowa, 1882.	O. S. Powell, River Falls, Wis., 1882.
No. of acres of cane grown	45	1	22	191	85	60
Tons stripped cane	270	....	190	580	700	486
Tons stripped cane per acre	6	....	8 64	3.04	8·24	8.1
Pounds of sugar made	4000	....	16,625	....	....	....
Gallons of molasses made	3600	190	2771	8150	9860	7268
Pounds of sugar per ton of cane	14 8	....	87 5	....	....	....
Gallons of molasses per ton of cane	13 3	....	14.6	14 1	14.1	15.0
Pounds of sugar per acre	89	....	756	....	....	....
Gallons of molasses per acre	80	190	140	42.7	116	121.1
Total value of product, dollars	2160	95	1386	4887	5020	5741
Total cost of product, dollars	1200	54	....	3287	1289	1245
Total profits, dollars	960	41	....	1500	3731	4496
Value product per acre, dollars	55.10	95	63.00	25 59	59.06	95 68
Cost product per acre, dollars	30.62	54	....	17 73	15 30	20.75
Profits product per acre, dollars	24.48	41	....	7.86	43 76	74 93
Total value product per ton cane, dol.	9.19	....	7.29	8.43	7.17	11 81
Profits per ton of cane, dollars	4.08	....	....	2 59	5 33	9.25
Seed per acre, bushels	....	....	....	8 5	20.0	5 0
Syrup sold for per gallon	60	56	60	50	50	60

	B. V. Ransom, Salem, Neb., 1881.	Thos. Johnson, Tenn., 1882.	Wm. Winton, Ill., 1882.	G. W. Allen, Kan.	D. H. Anderson, Kansas, 1882.	N. H. Scott, Wis., 1882.	Evan Erickson, Wis.
No. of acres of cane grown	14	5	40	25	30	14	10
Tons stripped cane	124	....	....	225.5	....	....	....
Tons stripped cane per acre	8 9	....	....	9	....	....	....
Pounds of sugar made	....	....	....	....	....	....	....
Gallons of molasses made	1488	500	5600	3000	3000	1400	1570
Pounds of sugar per ton of cane	....	....	....	....	....	....	....
Gallons of molasses per ton of cane	12.0		....	....	....	....	....
Pounds of sugar per acre	....	....	....	....	....	....	....
Gallons of molasses per acre	106.3	100	140.	120	100	100	157
Total value of product, dollars	786 20	250	2465	1125	1350	840	628 00
Total cost of product, dollars	352.50	122 50	1200	671 80	600	630	387.42
Total profits, dollars	433.70	127.50	1265.	453 20	750	210	240.58
Value product per acre, dollars	56.16	....	....	....	....	....	62.80
Cost product per acre, dollars	25 18	....	....	....	....	....	38.74
Profits product per acre, dollars	30.98	25.50	31.63	18.13	35.00	15.00	24.06
Total value product per ton cane, dol.	6.34	....	....	....	....	....	....
Profits per ton of cane, dollars	3.50	....	....	....	....	....	....
Seed per acre, bushels	10 0	....	....	....	....	....	....
Syrup sold for per gallon	50	50	40	37.5	45	60	....

	G. W. Allen, Kan.	C. Bozarth, Iowa.	Oak Hill Refin. Co., Ill.	O. S. Powell, Wis.	C. E. Thorne, Ohio.	M. O. Myrick, Wis.	Wm. Frazier, Wis.	B. V. Ransom, Nebr.	Evan Erickson, Wis.	Ill. and Ind. Univ., Ill.
Number of acres..........	25	85	1	1	1	1	3 41	14	10	1
Rent of land........	65.	212 50	3 00	2.00		2 00	10.	42.00	..	.....
Plowing	25.	127 50	2 50	1 25	3 00	1 50	9.	5.	20 50	10 00
Planting and cultivating..	75.	100 00	1 75	2 00	3 00	2 50	6.75	33.	36.00	.....
Hoeing.	12.	75 00	1 50	1 50	1 00	1 00	10.	....	....	..
Cutting cane.	79.	96 00	2 00	2 50	...	9 00	.....	.....		2.50
Hauling to mill............	57.	160 00	2 12	2 50	4 00	10 30	28.		55 37	6 00
Gathering seed	10.	.	2 00		2 00	1 00	... .	.....		2.00
Manufacturing...........	348.80	512 00	..	9.00	20 00	34 00	.....	258.	275 55	19.00
Total cost of one acre.....	26 87	15.09	.....	20 75	33 00	61 30		24 14	38.74	39.50
Cost manufact'g one acre	13.95	6.02	.....	9 00	20.00	34 00	.....	18 43	27.56	19 00
Cost of one acre at mill...	12.92	9.07	14.87	11 75	13 00	27.30	18 70	5.71	11 18	20 50
Profit on one acre....	18.13	43.76	7 86	74.93	16.00	30 00	26 35	30.98	24 06	54.00

The average net profits per acre of the entire 26 reports is $32.14, and the average net profit upon each ton of cane worked was $4.18; also the average number of tons of stripped cane produced per acre was 9.04, and the average value of the products of an acre was $74.64.

The average cost of an acre of sorghum, delivered at the mill for grinding was $14.50, and the average cost of manufacturing an acre of sorghum in syrup was $18.50. The average price of the syrup was slightly over 50 cents per gallon, and the sugar about 8 cents per pound.

It is to be observed, that very few make much account of the seed in their estimates; but since the value of this portion of the crop has been ascertained to be equal to that of the crop of corn for feeding purposes, it can not be left out in any plan for the most profitable production of syrup or sugar.

At Rio Grande, New Jersey, where this industry appears to be most permanently established, the seed is utilized in feeding and fattening swine, of which the company have several hundred, living exclusively upon the seed and bagasse of sorghum, and it is stated that the profits arising from this feature of their enterprise is such that the company

are enabled to grow their cane and deliver it to the mill absolutely free of all cost, so that the only expense of attending their production of sugar and syrup is that of manufacture.

Gratifying as is this result to those who desire to see the success of this new sugar industry, it can not be surprising to any one who will consider that our chief consumption of corn is for the fattening of swine, and that it is so used profitably needs no argument to prove. If, then, the seed of sorghum, equally abundant and equally nutritious, may be substituted for corn, the stalks of sorghum, like those of maize, may be regarded as being produced free of cost. Also, by means of such use of the seed and bagasse, fertilizing material is secured.

PRODUCTION OF SORGHUM SYRUP IN THE UNITED STATES ACCORDING TO THE CENSUS OF 1860-70-80.

States and Territories.	Number of gallons.		
	1860.	1870.	1880.
Massachusetts	....	....	18
Rhode Island	20	20	....
Connecticut	395	6,832	1,163
New York	516	7,832	1,134
New Jersey	396	17,424	1,261
Pennsylvania	22,249	213,373	69,767
Delaware	1,613	65,968	25,136
Maryland	907	28,563	19,837
Virginia	221,270	329,155	564,558
North Carolina	263,475	621,855	964,662
South Carolina	51,041	183,585	281,242
Georgia	103,490	374,027	981,152
Florida	....	....	10,199
Alabama	55,653	267,269	1,163,451
Mississippi	1,427	67,509	1,062,140
Louisiana	....	180	33,777
Texas	112,412	174,509	432,059
Arkansas	115,604	147,203	1,118,364
Tennessee	706,663	1,254,701	3,776,212
West Virginia	....	780,829	817,168
Kentucky	356,705	1,740,453	2,962,965
Ohio	779,076	2,023,427	1,229,852
Michigan	86,953	94,686	102,500
Indiana	881,049	2,026,212	1,741,853
Illinois	806,589	1,960,473	2,265,993
Wisconsin	19,854	74,478	314,150
Minnesota	14,178	38,725	543,369
Iowa	1,211,512	1,218,636	2,064,020
Missouri	796,111	1,730,171	4,129,595
Kansas	87,656	449,409	1,429,476
Nebraska	23,497	77,598	246,047
California	552	333	2,459
Oregon	315	....	2,283
Nevada	....	3,651	350
Colorado	....	....	3,227
Arizona	....	....	5,771
Dakota	20	1,230	17,012
Idaho	....	....	36
New Mexico	1,950	1,765	251
Utah	25,475	67,446	58,221
Washington	....	612	1,472
Total	6,749,123	16,050,089	28,444,202

It appears, from the above, that the increase in production from 1860 to 1870 was 138 per cent; and, from 1870 to 1880, 77 per cent, and that, with the exception of Pennsylvania, Ohio, and Indiana, no state with a large production shows any falling off; while, in certain of the states, the increase has been remarkable.

PRODUCTION OF SUGAR FROM SORGHUM.

Very many manufacturers of sorghum have produced amounts of sugar fairly comparable in quantity with the results obtained from sugar-cane.

Mr. A. J. Russell, who produced in 1879 over 22 tons of sorghum sugar, polarizing 96°.5, reports that he secured 15 to 23 gallons of syrup from a ton of cane, and obtained, as first sugar, $4\frac{1}{2}$ pounds to the gallon of syrup.

Mr. John B. Thoms, an experienced sugar maker, reports that sorghum sugar may be produced at an expense for manufacture of not over $1\frac{1}{4}$ cents per pounds.

Professor Henry, of Madison, Wisconsin, made sugar in 1882 at an expense for cultivation and manfacture of not over $4\frac{1}{2}$ cents per pound. He obtained, as "firsts," 45 per cent of the weight of the syrup in sugar of excellent quality; and upon their experimental plats, Professor Swenson and himself secured, approximately, a thousand pounds of sugar per acre.

The president of the Rio Grande Sugar Co. reported the expense of working the cane in the mill as not being over $1.75 per ton. Much of the cane yielded for each ton worked 65 pounds of first, besides the molasses; and, with sorghum in good condition as to maturity, the estimate of 100 pounds of sugar to each ton of cane is confidently made.

Mr. Thoms estimates the expense of working 100 tons of cane into syrup and sugar at $80.25 + $42 for 30 barrels, equal $122.25, or $1.22 for the manufacture of each ton of cane.

These results are such as have been often reported, even by those working with far more inexpensive plants.

Edwin Blood, of Stockbridge, Wisconsin, reports that, in the season of 1881, it cost him 11 cents per gallon to manufacture syrup, but in 1882 he could make it for $7\frac{1}{6}$ cents per gallon.

D. H. Anderson, of Kansas, reports 10 cents per gallon as the cost of manufacture of a gallon of syrup.

Now, at 15 gallons to the ton of cane, it costs at Rio Grande $11\frac{2}{3}$ cents, and Mr. Thoms $8\frac{1}{3}$ cents, to manufacture a gallon of syrup—results closely agreeing with the results obtained from smaller mills.

Reference to the average results of many samples of juice from many varieties of sorghum, given on page 210, will show that such estimate is far short of the possibilities.

Mr. A. J. Russell, already quoted, reports that he has obtained 280 gallons of syrup from one acre of cane, and obtained from this syrup 7½ pounds of sugar to the gallon. This is 2,100 pounds of sugar from the acre, besides the seed, which he estimates at from 25 to 40 bushels to the acre, and which he sold at 50 cents per bushel. He also reports that 10 tons of cane is an average yield to the acre, and 14 gallons of syrup to the ton, and 7½ pounds of sugar to the gallon; and that, at such yield, the sugar would not cost 2½ cents per pound; but he says that a good season and good land should give 20 tons of cane per acre, 17 gallons of syrup to the ton, and 9½ pounds of sugar to the gallon. This is a result of 3,230 pounds of sugar per acre.

Of the heavier and later maturing varieties of sorghum, over 30 tons per acre have been repeatedly obtained.

Geo. W. Chapman, of Stirling, Kansas, reports having obtained 33⅘ tons of Honduras sorghum to the acre, so that the above statements of Mr. Russell do not appear to be beyond the limits of possibility.

At Rio Grande, New Jersey, Hon. James Bishop, Secretary of the Bureau of Statistics of New Jersey, reports that, in 1882, the product of sugar and cane upon which the state paid bounty was 5,638 tons of cane and 319,944 pounds of sugar. Also, that 1,011 barrels of syrup were produced. That the average of the juice worked during the season was 11°.11 Beaumé, and the average purity of the juice was 84°.16. That the first two weeks of the season more molasses than sugar was produced, viz., 112 barrels of sugar and 181 barrels of molasses, but that, on the fourth week, the proportion was 130 barrels of sugar to 110 barrels of molasses.

One plat of eight acres, by actual survey and weight, yielded 136 tons of cane, an average of seventeen tons to the acre. Another plat of one acre yielded twenty-one tons, and a third twenty-two tons to the acre.

During the season of 1883, three acres, by actual measurement, yielded 78 tons of cane, an average of 26 tons per acre.

Sorghum Sugar in Japan.

Consul General Van Buren, of Yokohama, Japan, in a report to the Department of State upon the agriculture of Japan, under the head of sugar, says:

The sugar of Japan is made from that species of the sorghum plant known as the Chinese sorghum. It grows luxuriantly in all the southern portions of the empire south of the 36th degree of north latitude. The whole product of the

empire in 1878 was 64,297,580 pounds. Importation in 1878 was 67,434,805 pounds. For three or four hundred years, the processes of granulating and refining sugars have been known and practiced. Sorghum is not grown, as with us, from the seed, but from cuttings. In September, selected stalks are cut and buried in trenches a foot deep. Through the winter, from each joint of the stalks, sprouts grow. In the spring, these joints are cut off and set out in rows 15 to 18 inches apart, and about the same distance from each other in the rows. The ground has previously been thoroughly dug up and pulverized by a long-bladed mattock. The fertilizers used are ashes, fish, decomposed hay, straw and sea-weed, or night-soil. The plants are thoroughly hoed, hilled, and irrigated. In October and November, the leaves are stripped off, and the stalks are then cut and the hard outer covering is removed, and the remaining portion is then ground between rollers of stone or hard wood. The cane juice is then boiled in iron kettles until the granulation takes place, when it placed in bags and pressed dry. The expressed syrup is used as molasses. Dry upland soils are required for the successful growth of the cane, and the expenditure of labor and fertilizers is as great, if not greater, as for any other crop. Great exertions are being made to promote the increased production of sugar, which will probably be, in some degree, successful. In fact, I am informed that large orders for the apparatus for sugar making have been received from districts which have heretofore not grown sugar-cane.

Sugar Product per Acre.

Nelson Maltby, Geneva, Ohio, reports that E. Winchester, of that place, obtained, from one-third of an acre of sorghum, 336 pounds of sugar and 47 gallons of molasses; that M. D. Cole, from one-half an acre, obtained 330 pounds of sugar and 50 gallons of molasses; also, that, from 700 gallons of syrup, Mr. Maltby obtained 4,230 pounds of sugar from the first crystallization.

Professors Henry and Swenson, of Madison, Wisconsin, report, as the result from two experimental plats, 923 and 998 pounds of sugar per acre, and, in addition, 1,235 and 1,042 pounds of molasses, besides 27½ and 32 bushels of seed from the respective plats.

COMPARATIVE VALUE OF THE SORGHUM AND OTHER PRINCIPAL CROPS.

In the Iowa Agricultural Report for 1872, page 268, the following average acreage values of the leading crops grown in Iowa during the years 1862–'71, inclusive, is given as the report of a committee appointed for the purpose of investigating the sorghum industry in Iowa:

	Average acreage value of crop.	Difference.
Sorghum	$68 13	.....
Corn	13 26	$54 87
Wheat	13 79	54 34
Oats	11 73	56 40
Potatoes	55 84	12 29

It thus appears that the acreage value of the sorghum crop was more than five times (5.27) that of the average of the other cereals, and that the only crop which approached it in acreage value was that of potatoes. The average net profits of an acre of sorghum has been shown (page 415) to be $32.14, nearly three times the gross returns from the cereals.

For the purpose of comparison, the following tables from the Annual Report, Department of Agriculture, 1881–'82, are given, showing the average cash value of each of the principal crops grown in the United States, separately and together for each of the states; also, a summary of the amount of each crop grown, the acreage and value, average acreage yield and price, as also the statistics of maize and the cereals, as a whole, from 1871 to 1881, inclusive:

TABLE SHOWING THE AVERAGE CASH VALUE PER ACRE OF FARM PRODUCTS FOR THE YEAR 1881.

States.	Corn.	Wheat.	Rye.	Oats.	Barley.	Buckwheat.	Potatoes.	Tobacco.	Hay.
Maine	$30 94	$22 00	$16 05	$15 03	$18 70	$12 90	$40 04	.....	$10 41
New Hampshire	29 75	23 71	11 13	18 04	18 20	15 00	15 40	$225 12	10 57
Vermont	30 70	26 46	17 14	16 80	22 10	14 47	52 50	234 30	12 32
Massachusetts	22 09	23 70	18 26	19 76	24 32	9 97	55 00	228 00	20 83
Rhode Island	24 30	15 60	12 88	19 63	22 41	9 72	60	.	20 41
Connecticut	20 40	25 13	14 60	15 85	19 80	12 35	66 30	251 52	17 64
New York	20 33	19 04	11 16	13 82	21 95	9 76	49 59	174 86	16 30
New Jersey	17 86	18 16	10 48	15 04	16 30	9 00	62 40	129 00	20 54
Pennsylvania	18 90	16 75	10 08	15 26	20 04	9 70	46 56	152 49	14 88
Delaware	8 64	14 14	7 05	8 32	...	13 43	43 00	...	18 05
Maryland	15 49	15 79	10 80	9 26	28 38	9 00	48 41	54 08	17 64
Virginia	10 65	10 64	5 89	4 19	17 05	7 08	31 40	47 82	17 56
North Carolina	9 20	10 28	6 01	5 02	11 50	6 82	26 60	59 80	18 17
South Carolina	6 63	9 40	7 20	10 67	16 80	.....	21 31	34 72	19 36
Georgia	8 05	9 94	9 24	7 92	18 37	.....	21 00	33 88	21 55
Florida	8 80	8 41	7 84	7 54	...	.....	22 00	43 20	19 95
Alabama	9 60	10 43	8 15	8 10	13 15	.....	43 20	39 78	19 78
Mississippi	10 56	8 96	8 68	8 75	.....	...	36 80	48 79	18 94
Louisiana	12 74	4 95	12 18	12 28	....	.....	36 10	.....	17 82
Texas	11 78	17 78	16 80	16 35	17 37	.....	39 20	54 72	13 75
Arkansas	13 91	7 80	7 37	9 80	.	.....	43 56	40 66	18 00
Tennessee	8 93	8 30	5 60	7 95	14 63	6 97	34 40	41 80	16 22

Table Showing Average Cash Value, etc.—Continued.

States.	Corn.	Wheat.	Rye.	Oats.	Barley	Buckwheat.	Potatoes.	Tobacco.	Hay.
West Virginia	16 80	13 12	9 41	7 90	18 45	8 34	44 55	42 75	13 62
Kentucky	11 90	9 82	10 99	7 66	15 13	7 03	37 00	61 60	15 60
Ohio.	15 49	17 16	12 05	12 19	16 24	8 06	34 10	77 12	13 54
Michigan	17 64	13 62	11 37	15 01	22 60	13 05	46 40	62 25	15 12
Indiana	13 08	13 72	9 49	9 66	27 30	10 89	37 10	53 77	14 64
Illinois	11 25	10 00	14 10	11 36	13 33	7 52	50 40	54 20	14 82
Wisconsin	11 90	13 45	12 87	11 44	20 58	10 08	63 00	108 25	12 44
Minnesota	16 96	12 08	10 88	15 31	23 07	10 29	61 75	......	8 44
Iowa.	11 35	7 00	9 12	8 91	15 39	11 16	56 10	......	8 28
Missouri,	10 72	10 23	10 03	10 71	15 48	12 25	43 68	72 79	13 75
Kansas	10 56	9 55	9 03	7 92	9 22	9 40	49 40	......	5 83
Nebraska	10 69	6 89	7 88	7 92	4 89	7 86	47 04	....	5 40
California	21 22	12 36	11 10	13 86	14 55	17 90	68 00	......	16 47
Oregon	15 15	15 11	13 40	14 88	14 91	15 00	57 50	....	16 91
Nevada	21 80	17 40	. .	28 53	25 68	.....	121 50	....	19 50
Colorado	26 77	26 33	19 40	22 19	20 70	.....	104 00	......	24 00
Territories	30 59	19 33	16 36	17 79	17 89	....	70 70	......	14 88

TABLE SHOWING THE AVERAGE CASH VALUE PER ACRE OF THE CEREALS, POTATOES, TOBACCO, AND HAY OF THE FARM, TAKEN TOGETHER, FOR THE YEAR 1881.

States.	Average value per acre.	States.	Average value per acre.
Maine	$13 06	Arkansas	$13 06
New Hampshire	13 66	Tennessee	9 38
Vermont	15 28	West Virginia	14 69
Massachusetts	23 13	Kentucky	13 67
Rhode Island	23 29	Ohio.	15 76
Connecticut	22 41	Michigan	15 88
New York	17 79	Indiana	13 53
New Jersey	19 26	Illinois	12 23
Pennsylvania	17 00	Wisconsin	14 24
Delaware	11 71	Minnesota	12 72
Maryland	16 72	Iowa	10 03
Virginia	11 76	Missouri	11 18
North Carolina	9 81	Kansas	9 64
South Carolina	7 62	Nebraska	8 48
Georgia	8 37	California	15 26
Florida	8 72	Oregon	15 78
Alabama	9 68	Nevada	24 17
Mississippi	10 49	Colorado	26 89
Louisiana	13 03	Territories	19 58
Texas	12 76		

A GENERAL SUMMARY, SHOWING THE ESTIMATED QUANTITIES, NUMBER OF ACRES, AND AGGREGATE VALUE OF THE PRINCIPAL CROPS OF THE FARM IN 1881.

Products.	Quantity produced.	Number of acres.	Value.
Indian corn.........bushels..	1,194,916,000	64,262,025	$759,482,170
Wheat.........do.....	383,280,090	37,709,020	456,880,427
Rye.........do....	20,704,950	1,789,100	19,327,415
Oats.........do ...	416,481,000	16,831,600	193,198,970
Barley.........do. ...	41,161,330	1,967,510	33,863,513
Buckwheat.........do.....	9,486,200	828,815	8,205,705
Potatoes.........do....	109,145,494	2,041,670	99,291,341
Total.........	2,175,175,064	125,429,740	1.570,248,541
Tobacco.........pounds..	449,880,014	646,239	43,372,336
Hay.........tons....	35,135,064	30,888,700	415,131,366
Cotton.........bales..	5,400	16,710,750	259,016,315
Grand total.........	....	173,675,409	2,287,768,558

TABLE SHOWING THE AVERAGE YIELD AND CASH VALUE PER ACRE, AND PRICE PER BUSHEL, POUND, OR TON, OF FARM PRODUCTS FOR THE YEAR 1881.

Products.	Average yield per acre.	Average price per bushel.	Average value per acre.	Products.	Average yield per acre.	Average price per bushel, pound or ton.	Average value per acre.
Indian corn .bu..	18 6—	$0 63.6—	$11 82	Buckwheat .bu..	11.4+	$0 86 5+	$9 90
Wheat...... do.	10 2—	1 19 3+	12 03	Potatoes. .. do..	53 5—	90 9—	48 63
Rye.........do.	11 6—	93.3+	10 80	Tobacco. .. lbs..	696 1+	9.6+	..
Oats.........do.	24 7+	46 4—	11 48	Hay.......tons..	1 14	11 82	13 43+
Barley.........do.	20 9+	82 3—	17 21	Cotton......lbs..	155	10	15 50

CORN.

Calendar years.	Total production.	Total area of crop.	Total value of crop.	Average value per bushel.	Average yield per acre.	Average value of yield per acre.
	Bushels.	*Acres.*		*Cents.*	*Bushels.*	
1871.........	991,898,000	34,091,137	$478,275,900	48 2	29 1	$14 02
1872.........	1,092,719,000	35,526.836	435,149,290	39 8	30 7	12 24
1873.........	932,274.000	39,197,148	447,183,020	48 0	23 8	11 41
1874.........	850,148,500	41.036,918	550,043 080	64 7	20 7	13 40
1875.........	1,321,069,000	44,841,371	555.445,930	42 0	29 4	12 38
1876.........	1,283,827,500	49,033,364	475,491,210	37 0	26 1	9 69
1877.........	1,342,558,000	50,369.113	480,643,400	35 8	26 6	9 54
1 78.........	1,388,218,750	51,585,000	441,153,405	31 8	26 9	8 55
1779.........	1,547,901,790	53,085.450	580.486,217	37 5	29 2	10 93
1880.........	1,717,434,543	62,317,842	679,714,499	39 6	27 6	10 91
1881.........	1,194.916,000	64,262,025	759,482,170	63 6	18 6	11 82
Total.........	13,662,965,083	525,346,204	5,883 068,121	...	.	....
Ann'l aver'ge..	1,242,087,735	47,758,746	534,824,375	43.1	26	11 20

The average yield and value per acre for eleven years, from 1871 to 1881, inclusive, is thus comparatively presented:

Cereals.	Yield per acre.	Value per acre.
	Bushels.	
Corn	26 0	$11 20
Wheat	12 2	12 82
Oats	27 6	9 97
Rye	13 9	10 03
Barley	22.0	16 14
Buckwheat	16.1	11 37

RECAPITULATION OF CEREAL CROPS OF THE UNITED STATES.

Years.	Total production.	Total area of crop.	Total value of crop.
	Bushels.	*Acres.*	*Dollars.*
1871	1,528,776,100	65,061,951	911,845,441
1872	1,664,331,600	68,280,197	874,594,459
1873	1,538,892,891	74,112,137	919,217,273
1874	1,454,180,200	80.051,289	1,015,530,570
1875	2,032,235,300	86,863.178	1,030,277,099
1876	1,962,822,100	93,920,619	935,008 844
1877	2,178,934,646	93,150,286	1,035,571.078
1878	2,302,254,950	100,956,260	913,975,920
1879	2,437,482,300	102.260,950	1,245,127,719
1880	2,718,193,501	120,926,286	1,361,497,704
1881	2,066,029,570	123,388,070	1,470,948,200
Total	21,884,133,158	1,008,971,223	11,713,584,307
Annual average	1,989,466,651	91,724,657	1,064,871,301

In a letter to the committee of the National Academy of Sciences, C. Conrad Johnson, Esq., an experienced sugar-boiler, after a careful consideration of the results of the investigations made at the Department of Agriculture during the years 1878 to 1881 inclusive, makes comparisons between sorghum, sugar-canes, and beets, as sources for the economical production of sugar. His results will be examined with interest. He says as follows:

Having thus compared fully the chemical constituents of the canes under discussion, the processes best adapted for the attainment of the ends in view, together with such suggestions as may seem proper toward enabling the operation to be conducted with a minimum loss, we may return to the comparison of the actual results obtained in practice with the "available" ones presented by Dr. Collier in his tables. If we accept it as a fact that Louisiana cane will produce on an average 2,000 pounds of sugar and 120 gallons of molasses to the acre (and we believe that, taking the plant and ratoons together, this will be found a high estimate), we have the following data:

Average Louisiana cane:		
Sugar	pounds	2,000
Molasses	gallons	120

French beets:		
Sugar	pounds....	3,600
Molasses	gallons....	156
Sorghum-cane:		
Sugar (average)	pounds....	1,417 / 2,374
Molasses (estimated)	gallons)....	90 / 80

AGRICULTURAL EXPENSE.

Average cost of working per acre:	
Louisiana cane (estimated)	$14 00
French beets	14 00
Sorghum-cane	11 50 to 17 50

VALUE OF RESULTS.

Louisiana cane:		
Sugar		$140 00
Molasses		72 00
		212 00
French beets:		
Sugar		189 00
Molasses		16 38
		205 38
Sorghum-cane:		
Sugar (average)	$113 36 / 54 00	167 36
Molasses (estimated)	$189 72 / 48 00	*237 72

MARKETING OF SORGHUM SYRUPS.

The amount of sorghum sugar thus far produced, has had no appreciable effect upon the general market, and has been readily sold at fair prices in the local markets.

The production of syrups, however, has already reached such proportions as to have almost entirely supplied the demand in certain sections, and there is a great diversity in the prices received. The prices vary from 70 to 75 cents in certain places, to even 40 cents or less per gallon. It is without doubt true, that the quality varies as greatly as the price, and it is therefore a matter of great practical importance, not only to secure a good yield of cane, but a superior product from it—since the difference in cost of manufacture is at the most trifling between the best and poorest grades of syrup found in the market. To those who hope to establish a sure and permanent market for their syrup, it is of the greatest importance to secure a uniform product. This is more diffcult to the small manufacturer than the large, as usually the large works are able to retain the supervision

* In considering Mr. Johnson's paper, the committee of the National Academy of Sciences remark that "Mr. Johnson's estimate omitted the value of the seed of sorghum, an item which it is important to state, and which, in the opinion of many cultivators, is fully equal to the cost of cultivation, or more. Evidence on this point abounds in this report."

of a skilled person, and, besides, the large quantities made each day are of uniform quality. On the other hand, even the greatest care will hardly prevent the small manufacturer from now and then getting a portion of his syrup far below, or much above, his average product. It would be well if the syrups were, after cooling, put into large storage tanks, which, when the tanks were filled, could be barreled for market, thus securing at least many barrels of like character; and if two or three such tanks should be kept of different grades, the inferior product might be kept apart from the better.

To those desirous of securing for their products the highest market price, it will be found worth while to attend carefully to the packages in which the syrup is sent to market. Stout, clean casks give greater security in handling, and will generally more than pay any extra cost in the readiness with which a purchaser will be found.

Those who are satisfied as to the character of their syrups, should by means of a stencil plate attach their name to their packages, so that they may thus advertise their products, and secure permanent custom.

CENTRAL FACTORIES.

It will be found by far the most economical, if the central factory system should be generally adopted in place of many independent, and small factories. The advantages of such a system are obvious, since improved and necessary apparatus too expensive for the individual could be secured. Steam could be employed with the greatest economy, and the services of an experienced sugar maker could be secured. The economical production of sugar in the small factory is practically impossible; or, even if not in certain cases, its production by a well conducted central factory would be found far more profitable. The small farmer might then content himself either in growing the cane and delivering it to the factory; or, if at a distance, he might produce syrups of a high grade, *i. e.* containing a large amount of crystallizable sugar, and depend upon a local market for their disposal, or furnish them to the central factory to be worked for sugar and molasses, where a larger and better product could be secured than would be possible for him to obtain on his own farm. By this means a supply of syrup might be produced by the neighboring farmers sufficient to continue the work of the central factory during the winter, and until another crop—thus, not only keeping the necessary force for conducting it constantly employed, and the machinery always in running order, but having the expensive plant at no time of the year lying idle. Already such systems have been introduced in many of the industries of the farm, and, if wisely conducted, always with increased

profits and less labor. That such ultimately will be the result so soon as this new industry shall have been more generally entered upon, there can be no doubt; or, what is practically the same thing, large companies will be organized able to cultivate and manufacture several thousand acres of cane. A recent report of the Department of Agriculture says: "at one large factory there is reported a yield of 792 pounds of sugar, valued at 8 cents per pound, and 112 gallons of syrup, valued at 40 cents per gallon, from an acre, indicating a net profit of $50.67. It should be understood, however, that this encouraging result was not obtained by the ordinary manufacturer, but by chemists who were skilled in the manipulation of the juice, and who were working with apparatus designed especially for the manufacture of sugar." That intelligence in the conducting of such operations is of practical value none can doubt, and that sugar is to be made with apparatus designed for such purpose, goes without saying, but the report emphasizes the fact that the best results were secured by intelligent supervision, and improved appliances.

CHAPTER XIII.

(*a.*) Maize sugar, history of.
(*b.*) Detailed analyses of the juice of several varieties of maize.
(*c.*) Average results of analyses of many varieties of maize.
(*d.*) Sugar and ripe grain from maize.
(*e*) Comparison of the juices of sorghum and maize.
(*f.*) Pearl millet, sugar from.

MAIZE SUGAR, HISTORY OF.

The presence of sugar in the juice of the maize stalk has been long known. In the "True Travels, Adventures, and Observations of Captain Iohn Smith, Account of Sixth Voyage, A. D. 1606, London Ed., A. D. 1629," he says of Indian corn (Zea mais):

> The stalke being yet greene, hath a sweet iuice in it, somewhat like a sugar-cane, which is the cause that when they gather their corne greene they sucke the stalkes; for as we gather greene pease, so do they their corne, being greene, which excelleth their olde [Maize and Sorghum, F. L. Stewart, page 17].

The historian, Prescott, in his "Conquest of Mexico," says of the cultivation of Indian corn:

> The great staple of the country, as indeed of the American continent, was maize or Indian corn, which grew freely along the valleys, and up the steep sides of the Cordilleras, to the high level of the table-lands.

Prescott says:

> The Aztecs were as curious in its preparation, and as well instructed in its manifold uses, as the most experienced housewife. Its gigantic stalks, in the equinoctial regions, afford a saccharine matter not found to the same extent in northern latitudes, and supplied the natives with sugar little inferior to that of the cane itself, which was not introduced among them till after the conquest.

In the United States, in the early colonial days, it appears that experiments on a large scale were made, looking to the utilization of cornstalks as an economical source of sugar.

The entire acreage of all the cultivated land of the United States, including that in the cereals, root crops, cotton, and the grass lands, equals 132,910,281 acres. Of this area, 50,369,113 acres, or 38 per cent, is in maize. The enormous extent of this cereal becomes thus apparent.

The availability of these plants as a source of sugar has been known for a long time; but, although much has been known, little has been

done in the way of careful investigation for the purpose of determining their practical value for the production of sugar. Indeed, many of the statements made in reference to maize seem almost prophetic. It appears reasonably certain that had the matter been carefully followed up by a series of experiments, the enormous drain upon the country, which has required all the gold and silver product to supply, could not only have been prevented, but we might have been, a half century ago, the great sugar producing country of the globe.

In a letter from Abigail Adams to her husband, John Adams, September 24th, 1777, she says:

An instance may be seen in the progress which is made in grinding cornstalks and boiling the liquor into molasses. Scarcely a town or parish within forty miles of us but what has several mills at work; and had the experiment been made a month sooner, many thousand barrels would have been made. No less than 80 have been made in the small town of Manchester. It answers very well to distill, and may be boiled down to sugar. There are two mills fitting up in this parish. They have three rollers—one with cogs and two smooth. The stalks are stripped of the leaves and tops, so that it is no robbery upon the cattle, and juice ground out. 'Tis said four barrels of juice will make one of molasses, but in this people differ widely. They have a method of refining it, so that it looks as well as the best imported molasses.

David Lee Childs, on the culture of the beet and manufacture of beet sugar, says:

Other plants usually grown in our soil are capable of furnishing sugar, and some of them may be found worth cultivating for that and accessory products.

We have tried Indian cornstalks and the pumpkin, and have obtained from them good sugar and molasses.

Perhaps these crops may alternate advantageously with the beet. If the manufacture of sugar from the stalks of Indian corn can be reconciled, as we believe it may, with the maturity or near maturity of the ears, this source of saccharine may supersede the beet root.

Under date of March 13th, 1880, R. S. Hinman, of Hartford, Connecticut, writes me as follows:

I have found that, in 1717, one of my ancestors procured a patent from the general court of the colony of Connecticut to make molasses from cornstalks, on condition that he should make it as good and as cheap as it could be got from the West Indies.

At a meeting of the French Academy, M. Biot stated that he had found 12 per cent of sugar in juice from cornstalks in one experiment, and 13 per cent in another.

In the Farmers' Encyclopedia is the following:

The juice of maize contains as much, if not a larger proportion of sugar, than that of sugar-cane.

In Porcher's "Resources of Southern Fields and Forests," he says:

In the first place it has been satisfactorily proved that sugar of an excellent quality, suitable for common use without refining, may be made from the stalks of maize.

Again:

The sweetness of the cornstalk is a matter of universal observation. Our forefathers, in the Revolutionary struggle, resorted to it as a means to furnish a substitute for West India sugar.

Thaër, in his "Principles of Agriculture" (1844), says:

The use of unripe maize for the manufacture of sugar has lately been again recommended, on the ground that maize is better adapted for this purpose than beet root. I have long been of the opinion, he adds, that of all plants which can be raised in this country, maize is best suited to the purpose in question; the syrup extracted from it is, before crystallization, decidedly superior to that of beet root.

I have been recently informed that, over thirty years ago, there was a factory in the south of France which produced large quantities of excellent sugar from the stalks of maize, but the rapid development of the beet sugar industry caused this factory to decline, and their practical results have been almost forgotten. Also, about 1844, a certain judge, of Williston, Vermont, produced a fair quality of syrup from cornstalks; but his experiments, like those of so many others, caused only a temporary and local excitement, which speedily died away. The same is true as regards the sorghums.

EXAMINATION OF DIFFERENT VARIETIES OF MAIZE.

For the purpose of a thorough investigation of this matter, the author, as chemist of the Department of Agriculture, at Washington, planted several of the more common varieties of maize, and cultivated them according to the general method adopted when the grain is the object. The several varieties were subjected to daily examination during the season, in a manner identical with that employed in the examination of the sorghum, as described on page 185.

The varieties of maize planted were as follows:

No. 1. Egyptian Sugar Corn.
No. 2. Lindsay's Horse Tooth.
No. 3. Blount's Prolific.
No. 4. Improved Prolific Bread.
No. 5. Broad White Flat Dent.
No. 6. Long Narrow White Dent.
No. 7. Chester County Mammoth.
No. 8. 18-rowed Yellow Dent.
No. 9. Stowell's Evergreen.
No. 10. Improved Prolific.
No. 11. Sandford.
No. 12. Early Minnesota Dent.

Each of the above varieties were planted in plats having ten rows, 24 feet in each row, and the rows $3\frac{1}{2}$ feet apart. There was, therefore, of each variety planted $\frac{1}{52}$ of an acre, or 840 square feet.

In the above list of the varieties, it will be seen that white and yellow, flint and dent, common and sweet varieties, were included, so that the results secured may be regarded as by no means exceptional. Besides, these investigations were continued year after year, with several of these varieties, without any marked differences being manifest in the results obtained.

The following table gives the several stages of development of the plant, as mentioned in the tables of analyses, similar to those used in the case of the sorghums.

The examination of sugar, or sweet corn, since the grain is used in its immature condition, was continued with one portion of the plat after the 11th stage, at which time the ears were removed. The stalks were left standing in the field, and examined at intervals of one week after the ears had been plucked.

Stages of Development of Maize.

Stage—

1. About a week before the appearance of the tassel.
3. Tassel just appearing
5. Tassel entirely out.
7. Ear just appearing.
9. Ear just forming grain.
11. Ear in roasting condition.
13. One week after roasting condition.
15. Two weeks after roasting condition.
17. Three weeks after roasting condition.

Intermediate stages were recorded in the observations, but the above list is complete enough to enable the reader to understand the condition of the plants when examined.

The following table gives the average length and weight of the several varieties of maize, as also the number of stalks of each from which the averages were taken:

RELATIVE LENGTHS AND WEIGHTS OF THE SEVERAL VARIETIES OF MAIZE.

Name.	Number of stalks.	Length.	Total weight.	Stripped weight.
		Feet.	*Pounds.*	*Pounds.*
Egyptian Sugar Corn	58	8 35	1 710	1 105
Lindsay's Horse Tooth	38	8 93	2.933	1 833
Blount's Prolific	23	9 65	2.065	1 188
Improved Prolific Bread	23	10 03	2 865	1 791
Broad Flat White Dent	19	9 48	2 616	1 684
Long Narrow White Dent	19	9 13	2 874	1 658
Chester County Mammoth	22	8.49	2 732	1.459
18-rowed Yellow Dent	20	8 24	2 860	1 560
Stowell's Evergreen	32	6 08	0 816	0 610
Improved Prolific	26	7 37	1 923	1 485
Sandford Corn	49	5 94	0 662	0 426
Early Minnesota Dent	52	5 78	0 449	0.295

DETAILED ANALYSES OF THE STALKS OF SEVERAL VARIETIES OF MAIZE.

The following detailed analyses of one of the sugar corns, a yellow and a white dent, will give a general idea of the results obtained from each of the several other varieties examined:

EGYPTIAN SUGAR CORN.

Date.	Development.	Number of stalks.	Length.	Diameter at butt.	Total weight.	Stripped weight.	Juice expressed.	Specific gravity of juice.	Glucose in juice.	Sucrose in juice.	Solids not sugar.	Polarization.
	Stage.		*Feet.*	*Inch.*	*Lbs.*	*Lbs.*	*Pr. ct.*		*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*
June 13	......	8	2 5	8	...	....	67 30	1 016	.94	.25	1 92	.....
June 20	1	5	2 8	1 1	.	.....	69 10	1.014	1 17	.47	1 52	.....
June 27	2	[illegible]	2 9	1.0	.	....	78 10	1 015	2 20	.16	1.31	.....
July 5	3	1	5 2	.8	2 1	1 5	68 78	1 017	2 52	.05		....
July 14	3	1	7 3	.7	1 2	8	64 86	1 019	2 14	.69	2 81	....
July 16	4	1	7 5	.8	1 5	1.0	64 07	1 019	1 32	.74	4 90	....
July 11	5	1	7.5	1 1	2 3	1.7	66 96	1 021	2 38	.81	2 19	......
July 18	6	1	10 0	1.2	2 4	1 5	64 56	1 027	2 49	2.12	2.30	.....
July 18	7	1	8 0	1 2	2 2	1.4	63 67	1 025	3 29	.89	1 38	.....
July 20	8	1	9.4	1 1	2.4	1.3	68 57	1.026	2 92	....	2 92	.....
July 21	8	1	8 8	[illegible]	1 6	.8	62 28	1 029	2 50	3.97	3 05	.....
July 22	[illegible]	1	10.0	1 1	2.5	1.4	60.64	1 037	3 39	4 09	2.74	....
July 25	9	1	9.5	1 2	2.6	1 4	60.20	1 034	2 67	5 07	1.64	....
July 25	9	.....	....	.		...	..	1.035	2 61	3 76	2.03	....
July 26	10	1	10 0	1 4	3 6	1 8	62 95	1 039	3 07	5 07	2 01	....
Aug. 1	11	1	10.0	1 0	2.3	1.3	59.27	1 050	3 21	7 69	2 81	7.32
Aug. 6	11	1	8 0	.8	2 0	.9	63 26	1.036	4 17	3 94	2 12	3.28
Aug. 8	12	1	9 2	1.1	2.1	1.0	64 33	1 034	3 22	3 85	2 89	3 66
Aug. 9	11	1	9.3	.9	2.1	1.1	61 81	1.043	3 56	5 73	1 73	5.61
Aug. 13	13	1	9 1	1 1	2.6	1.1	57.46	1.039	2.41	5 71	1.07	.....
Aug. 17	13	1	9.5	1 0	2.3	1.2	57 00	1.038	3 50	4 34	1.99	3.18
Aug. 23	14	2	9 0	.9	3.3	1.7	53 99	1 053	2.19	9 27	2 03	7.92
Aug. 27	15	1	8.2	1 0	1.8	1 1	58 38	1 062	2 40	11 02	4 14	10.98
Aug. 31	16	1	9 2	1.3	2.1	1 3	54 71	1.040	2.74	4.72	3 11	.....
Sept. 2	17	1	9.0	1.0	1 5	1.0	57.30	1.061	2 59	12 80	1 95	10.84
Sept. 7	17	1	8.0	1 0	1 6	1.3	54 85	1.073	1.73	13 59	2.19	.....
Sept. 10	18	1	9.3	.9	1.3	.9	53.63	1.047	2.50	7.58	1.05	.....

EGYPTIAN SUGAR CORN.

Analyses made after the ears of corn had been plucked.

Date.	Number of days after stripping off ears.	Number of stalks.	Length.	Diameter at butt.	Total weight.	Stripped weight.	Juice expressed.	Specific gravity of juice.	Glucose in juice.	Sucrose in juice.	Solids not sugar.	Polarization.
			Feet.	*Inch.*	*Lbs.*	*Lbs.*	*Pr. ct.*		*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*
Aug. 9	0	1	9 3	.9	2 1	1.1	61.81	1.043	3.56	5.73	1.73	5 61
Aug. 18	7	1	11 0	1 1	1.8	1 4	60 16	1 055	3 24	7 60	2 38	13.87
Aug. 18	7	1	9.5	1 1	1 8	1 4	60 60	1 047	2 98	7 46	1.92	7 54
Aug. 23	14	2	9 5	1.2	2 7	2 3	63 88	1 049	2 82	8.13	1.92	7 28
Aug. 23	14	2	9.0	1.1	2 3	2 0	55 35	1 050	3 45	7.24	2.45	7.34
Aug. 30	21	1	9 0	1 1	1.3	1 2	56 57	1 053	1 66	9 69	Lost	10 04
Aug. 30	21	1	8.2	1.0	1 5	1 3	61 19	1.057	1.89	10 33	Lost.	8 96
Sept. 1	21	1	7 8	1 0	1.3	1 0	60 00	1.061	1.76	12 57	1.03	.
Sept. 1	21	1	7 6	1 1	1 5	1 1	59 02	1.060	2.18	11 20	2.18	10 39
Sept. 1	21	...	......	.....	.....	....	...	1.061	2 46	11.17	1.63	10 49
Sept. 5	28	1	9 4	1 1	1 1	8	50 14	1 071	5.41	9.91	3 35	....
Sept. 5	28	2	9.0	.9	1 5	1 3	51 12	1 060	3.85	9 10	2 61	
Sept. 8	28	2	8 0	1.1	1 8	1 5	51 79	1 065	2.26	11.73	2 20	11 40
Sept. 8	28	2	9.0	1 0	1 8	1 5	55.21	1.059	2.57	11.34	1 19	10.55

LONG NARROW WHITE DENT.

Date.	Development.	Number of stalks.	Length.	Diameter at butt.	Total weight.	Stripped weight.	Juice expressed.	Specific gravity of juice.	Glucose in juice.	Sucrose in juice.	Solids not sugar.	Polarization.
July 7	1	1	4.3	1.3	2 7	2.0	68 84	1.019	2.21	.23	1 71	.....
July 15	2	1	7.5	1.0	1 9	1 4	60 27	1 024	2 41	1 83	3 96	.....
July 21	3	1	7.0	.8	1.5	1.0	65 97	1 029	3.54	1.43	2 56	.....
July 21	4	1	7.8	.8	1 8	1 2	65 37	1.026	3 27	1.04	3 29	....
July 21	5	·1	7 8	1 1	2.4	1 6	60 27	1 023	3 48	1.60	2 34	....
July 26	6	1	9 7	1 1	1 9	1.3	60 96	1 032	3.15	3.56	2.10	2 80
July 26	7	1	9 5	1.2	2.2	1.4	56 83	1.033	3 69	3.05	2.16	...
Aug. 1	8	.....	.....	.....	.....	....	....	1 045	3 56	3 34	3 10	.....
Aug. 1	8	1	10 0	1 1	3 7	1.9	59 77	1.046	3.16	5 81	3.12	5 36
Aug. 9	9	1	10.3	1 1	3 2	1.9	56 96	1 041	4.50	4 40	1 47	3 65
Aug. 12	10	1	10 2	1.1	3 6	1.6	59 70	1 053	4 41	8 32	2 27	8.03
Aug. 18	11	1	10 4	1 1	4 0	1 7	62 77	1 049	2.58	6 90	2 48	7 03
Aug. 23	12	1	9 2	1 5	4.5	2 3	62 34	1 059	1 97	10 67	2 32	10.49
Aug. 24	13	1	10.6	1 2	2 7	1 8	53 58	1 048	2 53	7 34	2 25	.....
Aug. 26	13	1	9.8	1.2	4 3	2.1	52.05	1 062	2 36	11.62	1.98	11.51
Aug. 26	13	....	....	......	.....	....	... .	1 062	2 36	11.74	1 90	11 63
Aug. 27	14	1	9 5	1 1	3 3	1.7	57.73	1.048	3 16	7.59	2.75	7 28
Aug 31	15	1	10 0	1 4	3.4	1 6	53 55	1 042	1.55	5.20	3.99	5.26
Aug. 31	15	....	......	.....	.....	..	... ...	1 042	1 61	5.42	3.62	. .
Sept. 2	16	1	9.5	1.0	2.2	1.4	45.95	1.056	3 25	9 51	3 24	9.39
Sept. 7	17	1	9 8	.9	1.5	1 1	56.00	1 065	1 84	12 11	2 52	13 81
Sept. 10	18	1	10 5	1.3	3 8	2 5	55.47	1 058	2 56	10 59	2 06	10 20
Sept. 10	18	......	......	.....	.....	......	....	1 058	2.51	10 30	2.31	10 29

EIGHTEEN-ROWED YELLOW DENT.

Date.	Development.	Number of stalks.	Length.	Diameter at butt.	Total weight.	Stripped weight.	Juice expressed.	Specific gravity of juice.	Glucose in juice.	Sucrose in juice.	Solids not sugar.	Polarization.
			Feet.	*Inch.*	*Lbs.*	*Lbs.*	*Pr. ct.*		*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*
July 7	1	1	5 2	1.3	3 3	2.4	65 36	1.022	3 58	.35	1.79	......
July 15	2	1	6.0	1.1	1 8	1.2	62 38	1.023	3 64	.48	3 21	......
July 15	3	1	5 5	1.3	2 8	1.9	62 32	1 023	2 86	65	4 89	......
July 18	4	1	8 0	1 3	3 0	1 6	63.47	1 028	2 49	1 89	5 34	.....
July 21	5	1	7.6	1.0	1 9	1.3	62 84	1.028	3 86	1 57	3 83	.....
July 21	6	1	6 5	1.1	2 0	1 2	60 17	1.031	4 21	2 07	2 98	.....
July 21	7	1	8 1	1 2	2 3	1.5	60 09	1 028	3.95	2.23	2 67	.....
July 26	8	1	9 2	1.2	2 6	1 5	61 03	1 032	3 96	3 36	1 40	...
Aug. 1	[illegible]	1	8 5	1 1	3 5	1.7	60 62	1 043	3 65	5 17	2 92	....
Aug. 9	10	2	8 5	1.1	5 8	2 4	54 82	1.044	3 05	6.87	1.38	6.40
Aug 12	11	1	10 2	1 3	4 2	2.0	54 90	1 052	3 20	8 24	2.81	7.58
Aug 18	12	1	8 5	1.3	3.7	1.3	55 40	1.036	3 35	4 15	2 05	?7.48
Aug. 24	13	1	10.2	1.6	4 3	2.3	58.44	1.050	1 50	9 20	1 81	8 56
Aug. 24	13	.....	.	....	...	....	....	1.049	1 46	13 60	-2 48	8.69
Aug. 26	13	1	10 0	1 4	3 4	2.2	49 80	1.060	1 32	11.56	2 54	10.77
Aug. 26	13	..	.....	.....	....	.....	....	1.061	1 53	11.48	2 07	10 76
Aug. 27	14	1	7 7	1.1	2.8	1 4	59.38	1 051	2.80	8 13	3.39	8 34
Aug. 31	15	1	9 0	1.3	2 3	1.2	49.64	1 045	3 22	6 18	2.56	...
Sept. 3	16	1	8 1	1 3	2 1	1 5	50 00	1 062	2 11	11 39	?5.80	11.44
Sept. 7	17	1	9 0	1.2	2 3	7	37 94	1.030	1 20	?4 35	2 12	.. ..
Sept. 10	18	1	9.7	1.6	3.1	1 9	63 53	1 057	1 56	11 79	2.78	10 86
Sept. 10	18	....	.....	....	.. ..	...	....	1 057	1.59	11 52	2 50	10.84

The several varieties were planted April 30th, so that the date of each analysis will enable the reader to determine the time necessary to reach the different stages:

The following table presents the results of the foregoing analyses by each stage, as has been explained in the analyses of sorghums, page 191; the average results of the analyses under each stage being given, as also a column giving the number of analyses thus averaged:

EGYPTIAN SUGAR CORN.

Analyses made after the ears of corn had been plucked.

Number of days after stripping.	Average date of estimation.	Observed date of reaching stage.	Number of determinations.	Glucose.	Sucrose.	Solids not sugar.	Total solids.	Per ct. of sucrose polarization.	Available sucrose.	Average juice.	Average specific gravity.
				Pr. ct.	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	
7...........	Aug. 18.	Aug. 13.	2	3.11	7.53	2.15	12.79	7.54	2 27	60 38	1.051
14...........	Aug. 23.	Aug. 18.	2	3.13	7.68	2.18	12.99	7.31	2 37	59.61	1.049
21...........	Aug. 31.	Aug. 23.	5	1.99	10.99	1.61	14.59	9.97	7.39	59.19	1.058
28...........	Sept. 6.	Aug. 30.	4	3.52	10.52	2.34	16.38	10.98	4.66	51.65	1.064

28

Egyptian Sugar Corn—Continued.

Stage.	Average date of estimation.	Observed date of reaching stage.	Number of determinations.	Glucose.	Sucrose.	Solids not sugar.	Total solids.	Per ct. of sucrose polarization.	Available sucrose.	Average juice.	Average specific gravity.
				Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.		Pr. ct.	Pr. ct.	
Before 1	June 13	June 13	1	.94	25	1 92	2.11	....	.....	67.30	1 016
1	June 20	June 20	1	1.17	.47	1.52	3.16	....	......	69.10	1 014
2	June 27	June 27	1	2 20	.16	1 31	3 67	......	....	78.10	1.015
3	July 10	July 5	2	2 33	37	2 81	5 51	......	......	66 82	1 018
4	July 16	July 9	1	1.32	.74	4 90	6 96	......	......	64 07	1 019
5	July 11	July 11	1	2.38	.81	2 19	5.38	.....	.....	66 96	1 021
6	July 18	July 15	1	2 49	2.12	2 30	6.91	......	......	64 56	1 027
7	July 18	July 18	1	3.29	89	1 38	5 56	....	....	63 67	1.025
8	July 21	July 19	3	2.94	4 06	2 90	9 87	......	..	63 83	1 031
9	July 25	July 20	2	2 64	4 42	1.84	8 90	.	.....	60 20	1 035
10	July 26	July 25	1	3 07	5 07	2.01	10 15	.....	.	62.95	1.039
11	Aug. 4	July 30	2	3 65	5 79	2 22	11 66	5.30	...	61.45	1.043
12	Aug. 8	Aug. 5	1	3.22	3 85	2 89	9 96	3 66	—2 26	64.33	1.034
13	Aug. 15	Aug. 14	2	2 96	5 03	1 53	9 52	3 18	.54	57.23	1 039
14	Aug. 23	Aug. 17	1	2 19	9 27	2 03	13 49	7.92	5.05	53 99	1 053
15	Aug. 27	Aug. 19	1	2 40	11 02	4 14	17.56	10 98	4.48	58.38	1.062
16	Aug. 31	Aug. 26	1	2 74	4 72	3 11	10.57	....	—1.13	54.71	1 040
17	Sept. 4	Aug. 30	2	2 66	13 20	2.07	17 93	10.84	8.47	56.08	1.067
18	Sept. 10	Sept. 6	1	2 50	7 58	1 05	11.13	.....	4.03	53.63	1.047
					LONG NARROW WHITE DENT.						
1	July 7	July 15	1	2.21	.23	1.71	4.14	......	......	68.84	1 019
2	July 15	July 16	1	2.41	1.83	3.96	8.20	....	......	60.27	1.024
3	July 21	July 18	1	3 54	1.43	2 56	7.53	. . .	...	65.97	1.029
4	July 21	July 19	1	3 27	1 01	3 29	7.60	......	......	65 37	1 026
5	July 21	July 20	1	3 48	1.60	2 34	7 42	......	......	60 27	1.023
6	July 26	July 25	1	3.15	3 56	2.10	8.81	2 80	......	60 96	1.032
7	July 26	July 28	1	3 69	3.05	2 16	8 90	....	.....	56 83	1.033
8	Aug. 1	July 30	2	3 36	5 57	3 11	12 04	5 36	....	59 77	1 045
9	Aug. 9	Aug. 3	1	4 50	4.40	1 47	10 37	3 65	—1.57	56 96	1 041
10	Aug. 12	Aug. 5	1	4 41	8 32	2.27	15 00	8 03	1.64	59.70	1.053
11	Aug. 18	Aug. 11	1	2 58	6 90	2 48	11 96	7 03	1 84	62.77	1.049
12	Aug. 23	Aug. 15	1	1 97	10 67	2 32	14.96	10 49	6.38	62 34	1.059
13	Aug. 25	Aug. 17	3	2 42	10.23	2 04	14 69	11.57	5.77	52 81	1.057
14	Aug. 27	Aug. 19	1	3.16	7 59	2 75	13 50	7 28	1.68	57 73	1.048
15	Aug. 31	Aug. 23	2	1.58	5 31	3 80	10 69	5 26	—.07	53 55	1 042
16	Sept. 2	Aug. 27	1	3 25	9.51	3.24	17.00	9.39	3.02	45.95	1.056
17	Sept. 7	Aug. 30	1	1 84	12 11	2.52	16 47	. . .	7.75	56.00	1.065
18	Sept. 10	Sept. 2	2	2.53	10 44	2.18	15.15	10.25	5.73	55.47	1.058
					EIGHTEEN-ROWED YELLOW DENT.						
1	July 7	July 11	1	3 58	.35	1 79	5 72	. .	.....	65.36	1.022
2	July 15	July 15	1	3 64	.48	3.21	7 33	.....	. . .	62 38	1 023
3	July 15	July 16	1	2 86	.65	4.89	8 40	....	.. ...	62.32	1.023
4	July 18	July 18	1	2 49	1.89	5.34	9 72	...	...	63.47	1 028
5	July 21	July 19	1	3.86	1.57	2 83	8 26	.....	....	62.84	1.028
6	July 21	July 20	1	4 21	2.07	2 98	9.26	.....	....	60.17	1.031
7	July 21	July 25	1	3 95	2.23	2.67	8.85	....	....	60.09	1 028
8	July 26	Aug. 5	1	3 96	3 36	1 40	8 72	. . .	. . .	61.03	1 032
9	Aug. 1	Aug. 11	1	3 65	5 17	2.92	11 74	.	—1 40	60 62	1.043
10	Aug. 9	Aug. 15	1	3.05	6.87	1.38	11 30	6 40	2.44	54.82	1 044
11	Aug. 12	Aug. 19	1	3 20	8 24	2.81	14.25	7 58	2.23	54 90	1 052
12	Aug. 18	Aug. 20	1	3.35	4.15	2 05	9 55	?7.48	—1 25	55 40	1.036
13	Aug. 25	Aug. 23	4	1 47	11 46	2 14	15 07	9.77	7.85	54 12	1.055
14	Aug. 27	Aug. 25	1	2.80	8 13	3.39	14 32	8.34	1.94	59.38	1.051
15	Aug. 31	Aug. 28	1	3.22	6 18	2 56	11 96	. .	.40	49.64	1.045
16	Sept. 3	Aug. 30	1	2.11	11 39	5.80	19 30	11.44	3.48	50.00	1.062
17	Sept. 7	Sept. 3	1	1.20	4 35	2 12	7 67	.....	1.03	37 94	1 030
18	Sept. 10	Sept. 6	2	1.57	11.65	2.64	15.86	10.85	7.44	63.53	1.057

The following table gives, by stages, the average results of the analyses of the twelve varieties examined. It will be observed that there is a general resemblance to the results shown on page 194, of the examination of the sorghums—a gradual increase in specific gravity of the juice and in the content of sugar; but an inspection of the detailed analyses shows that this is not as constant as with the sorghums, and that the juice does not reach at any time the high content of sugar which was found in the sorghum juices.

But that this is often so high as to give reason for belief that even cornstalks may be found a profitable source of sugar will appear, when we consider that, of the analyses made of ten varieties of maize grown in 1880, the juice gave, of crystallizable sugar, as follows:

124 analyses of 10 varieties gave over 9 per cent.
90 analyses of 10 varieties gave over 10 per cent.
59 analyses of 9 varieties gave over 11 per cent.
24 analyses of 9 varieties gave over 12 per cent.
8 analyses of 4 varieties gave over 13 per cent.
2 analyses of 1 variety gave over 14 per cent.
1 analysis of 1 variety gave over 15 per cent.

And of eight varieties grown in 1881, seven of which were common field maize,

3 analyses of 3 varieties gave over 13 per cent.
9 analyses of 7 varieties gave over 12 per cent.
22 analyses of 7 varieties gave over 11 per cent.
29 analyses of 7 varieties gave over 10 per cent.
35 analyses of 7 varieties gave over 9 per cent.

GENERAL RESULTS OF ANALYSES OF MAIZE BY STAGES.

	Number of determinations.	Glucose. Pr. ct.	Sucrose. Pr. ct.	Solids not sugar. Pr. ct.	Average juice. Pr. ct.	Average specific gravity.	Available sucrose. Pr. ct.	Per cent sucrose by polarization.
Before first stage	6	1.37	.33	1.77	68.36	1.016	....	......
First stage	11	2.49	.38	2.09	64.39	1.019	......	......
Second stage	8	2.77	.64	2.70	66.92	1.021	......	......
Third stage	9	2.81	.74	2.98	64.22	1.025	....	......
Fourth stage	9	2.88	1.43	3.42	61.76	1.028	.....	......
Fifth stage	10	2.96	1.33	2.75	64.86	1.025	......	......
Sixth stage	[illegible]	3.37	2.19	2.44	63.85	1.030	....	1.85
Seventh stage	9	3.09	1.91	2.63	51.42	1.029	.....	2.49
Eighth stage	14	2.84	4.39	2.76	62.20	1.035	...	5.00
Ninth stage	10	2.92	6.25	2.00	60.25	1.041	1.33	6.27
Tenth stage	10	3.17	6.26	2.46	56.77	1.045	.63	6.04
Eleventh stage	11	2.86	5.61	2.53	58.13	1.042	.22	5.33
Twelfth stage	11	2.64	5.86	2.58	58.57	1.042	.64	5.55
Thirteenth stage	16	2.27	8.38	2.06	55.72	1.048	4.05	7.62
Fourteenth stage	9	2.36	7.56	2.74	56.78	1.045	2.46	7.08
Fifteenth stage	10	1.92	5.95	3.10	55.59	1.043	.93	7.73
Sixteenth stage	7	2.18	6.17	3.64	49.36	1.044	.35	7.95
Seventeenth stage	10	1.69	9.12	2.51	55.06	1.051	4.92	9.36
Eighteenth stage	9	1.92	8.83	2.37	54.88	1.049	4.54	8.39

It is to be remembered that maize has been grown for centuries as a source of grain only, and to that end varieties have been selected and developed. It is found, even now, that very great differences exist in the several varieties, in regard to the juicy character of the stalk and in its content of sugar. Some varieties have a spongy stalk, quickly drying up, and yielding little juice upon pressure; others have, even when the grain is quite hard and ripe, a heavy, juicy stalk, resembling the sugar-cane or sorghums, and this juice is found to be rich in sugar. Differences quite as great are found in the sorghums, as will be seen upon page 101; and it is quite possible, if not even probable, that, by a few years of careful selection, varieties of maize may be grown, the stalks of which shall be more valuable for sugar than is the crop for grain, even though the product of this may be but little diminished.

The following tables give the acidity of two varieties of maize juices—one sweet, the other field maize—which may be compared with similar tables for sorghum juices upon page 253:

CORN JUICE, ACIDITY.

Egyptian Sugar Corn.

Date.	Stage.	c. c. of $\frac{N}{50}$ HNaO for 100 c. c. of juice.	Specific gravity of juice.	Per cent of acid as malic.
July 25	9	93	1.034	121
26	10	152	1.030	.197
Aug. 1	11	122	1.050	.156
[illegible]	11	152	1.036	.197
8	12	140	1 034	.181
9	11	124	1.043	.159
17	13	164	1.038	.211
18	14	184	1 083	.228
23	14	92	1.053	.117
27	15	148	1.062	.186
31	16	136	1.040	.175
Sept. 2	17	80	1.061	.100
7	17	104	1.073	.129
10	.....	132	1.042	.169
10	18	148	1.047	.190

Lindsay's Horse Tooth Corn.

Date.	Stage.	c. c. of $\frac{N}{50}$ HNaO for 100 c. c. of juice.	Specific gravity of juice.	Per cent of acid as malic.
July 25	9	152	1.033	.197
26	9	128	1.030	.166
Aug. 1	11	156	1.040	.201
1	10	132	1.050	.168
6	11	118	1.041	.151
8	12	112	1.040	.144
23	14	112	1.042	.144
27	15	140	1.041	.180
31	16	116	1.050	.148
Sept. 2	17	56	1.056	.071
7	17	64	1.032	.083
10	18	124	1.061	.157

Analyses of Maize Stalks.

The following table shows the average results of numerous analyses of several varieties of maize. In these averages, every analysis made during the entire period is included, and none were made until the grain was so far matured as to be at its best for feeding purposes.

The average weights of the canes are a little different from those given on page 431, but those are the average weights of those stripped stalks which were analyzed, the table upon page 439 being of all the stalks cut of each variety.

If maize was grown in drills $3\frac{1}{2}$ feet apart, and the plants were 6 inches apart in the row, there would be 24,960 plants per acre. Upon first rate corn land such a crop is possible, and there is a column giving the results per acre upon an estimate of such a crop. In one plat there were grown at the rate of 23,150, not allowing for those carried away by boys. There are also given the actual results obtained on the small experimental plats, calculated to the acre.

The stalks give an average result in juice fairly agreeing with the several varieties of sorghum, and the specific gravity is also fairly good; but the relative amount of impurities in the juices, as compared with the sucrose, is larger than in the sorghums.

There is an idea prevalent among farmers, that the stalks of maize are dry and juiceless when the grain is ripe, but this is quite erroneous, as any one may for himself determine. Owing to the practice of either topping the corn and allowing the ears to dry upon the butt, which is left standing in the field, or, more commonly, of cutting up the corn, and then, even after months, husking out the ears, the stalks, though juicy when topped or cut, speedily dry out.

It appears that some other arrangement for drying and curing the ears could be devised, so that the sugar in the stalk could be secured. In the case of sweet or sugar corn, which is used for canning, there appears no reason why the stalks should not be utilized, since these stalks retain their content of sugar for weeks after the ears have been plucked.

It seems that judicious use of these stalks would add greatly to the profits of an industry which has reached very great proportions in our country.

TABLE SHOWING THE COMPARATIVE VALUE, DURING THE WORKING PERIOD, OF ALL VARIETIES OF CORN STALKS EXAMINED.

Number.	Varieties of corn.	Number of days for working.	Number of analyses.	Average weight of stripped stalks.	Average per cent of juice.	Average specific gravity of juice.	Average per cent sucrose in juice.	Average per cent glucose in juice.	Average per cent other solids in juice.	Average per cent available sugar.	Average per cent total sugars.	Actually obtained.				Computed at 24,000 stalks per acre.			
												Stripped stalks per acre.	Juice per acre.	Available sugar per acre.	Total sugar per acre.	Stripped stalks per acre.	Juice per acre.	Available sugar per acre.	Total sugar per acre.
				Lbs.								*Lbs*	*Lbs*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
1	Egyptian Sugar Corn	87	23	.97	56.40	1057	9.05	1.77	2 94	4.34	10 82	14,084	7,943	345	859	23,280	13,130	570	1421
2	Lindsay's Horse Tooth..........	70	41	1 71	59 67	1055	9 16	1 00	3.28	4.88	10 16	24,753	14,770	721	1501	41,040	24,489	1195	2488
3	Blount's Prolific..	35	10	1.02	57 26	1038	5.69	1.71	3 06	.92	7 40	......	......	.....	....	24,480	14,017	129	1037
4	Improved Prolific Bread........	28	12	1.48	56.26	1040	5 47	2 29	2.63	.55	7 76	......	......	......	..	35,520	19,983	110	1551
5	Broad White Flat Dent	70	19	1 53	59 36	1051	8.27	1 03	3 13	4 11	9 30	22,256	13,211	543	1229	36,720	21,797	896	2027
6	Long Narrow White Dent.......	70	33	1 51	58 01	1055	9.15	1 27	2 94	4 94	10 42	21,929	12,721	628	1326	36,240	21,023	1039	2191
7	Chester County Mammoth	87	22	1 08	55 89	1059	9 31	94	3.81	4 56	10.25	15,642	8,744	399	896	25,920	14,487	661	1485
8	Eighteen-Rowed Yellow Dent...	29	12	1 61	53.23	1051	9 75	2 07	2 46	5 22	11 82	....	......	..	...	38,640	17,907	935	2117
9	Stowell's Evergreen.............	35	13	.61	54 58	1057	9.92	1 41	3 30	5 21	11 33	8,835	4,822	251	546	14,640	7,991	416	905
10	Improved Prolific...............	70	19	1 49	56.51	1049	7.21	1.18	3.20	2 83	8 39	21,562	12,185	345	1022	35,760	20,208	572	1695
11	Sanford Corn................ ...	52	12	.43	50 92	1055	8.62	1 28	3 78	3 56	9 90	6,187	3,150	112	312	10,320	5,255	187	520
12	Early Minnesota Dent....... ..	56	15	.30	39.40	1061	9.46	1.11	4.66	3.69	10 57	4,278	1,686	62	178	7,200	2,837	105	300

From the above table it will be seen, that five of the above varieties of field corn gave an average yield of available sugar of 527 pounds to the acre, with a reasonable possibility of averaging 873 pounds per acre. That is, the sugar present in the juice, was in this excess above the sum of glucose and other solids, and our experiments have shown that this available sugar may be increased by properly making the syrup, see page 309.

It will be seen that these five varieties also give as the average of the total sugars per acre 1,195 pounds, with a reasonable possibility of 1,977 pounds per acre, which is equal to from 1,553 to 2,570 pounds of syrup, by allowing, as is correct, 70 per cent of total sugars for syrup. This would be equal to a product of from 124 to 206 gallons of syrup per acre, allowing 12½ pounds to the gallon. The average actually obtained was 124 gallons, and the 206 is at least possible.

Besides the above results embodied in the table, there were made seven separate analyses of bundles of sugar corn stalks, from which the ears had been removed for canning from 1 to 6 weeks before the stalks were cut and examined. As these stalks were from a field of over 2,000 acres, the entire product of which was used for canning purposes, the results are perhaps of greater practical interest. The average available sugar in the juices of the seven lots was 6.38 per cent.

The average of 57 analyses of 9 varieties of common field corn stalk, taken for analyses from 1 to 6 weeks after the ears had been removed for roasting, was as follows:

Per cent juice expressed	52 66
Specific gravity of juice	1.0646
Per cent sucrose in juice	10 88
Per cent glucose in juice	1.04
Per cent other solids in juice	4 10
Per cent available sugar in juice	5 74

This would give 1,053 pounds of juice, and 60½ pounds of available sugar, to each ton of stalks, or 13 gallons of syrup.

Sugar from Corn Stalks.

The author has made many experiments for the purpose of extracting the sugar from maize stalks, and in every case secured such a result as the character of the juice indicated. All of the experiments were by open pan evaporation, so that there would appear to be no trouble in more than reaching such results upon a large scale. The sugar extracted amounted in several experiments, in 1878, to 32 per cent, in 1879, to 39.3 per cent, and in one case to 47 per cent, of the weight of the syrup made. This sugar was by many preferred to the raw sorghum sugar. In taste, it much resembled maple sugar.

An experiment made with the stalks of Egyptian sugar corn, taken after the ears had been plucked for canning, was as follows:

621 pounds stalks with leaves and tops.
240 pounds leaves and tops.
381 pounds stripped stalks.
159 pounds juice expressed.
10.63 specific gravity of juice.
41.7 per cent of juice from stripped stalks.
30.33 pounds of syrup made.
19.1 per cent syrup in juice.
14.25 pounds sugar extracted from syrup.
47 per cent of sugar extracted from syrup.
16.08 pounds of molasses remaining.

The above is equal to a yield from each ton of stripped stalks of 74.8 pounds of sugar, and 84.4 pounds, or 6.75 gallons, of molasses.

Nelson Maltby, of Geneva, Ohio, reports a similar result, January 8th, 1883, as follows: "I cut 200 pounds of corn stalks, when the ear was just fit for use. It made one gallon of syrup, and from this, I obtained 3½ pounds of sugar. I think I can improve upon this next time." His result is about 35 pounds of sugar, and 7.2 gallons of molasses to a ton of stalks.

SUGAR AND RIPE GRAIN FROM MAIZE.

A small plat of three varieties of field corn (Lindsay's horse tooth, Improved Prolific, White Dent), planted in drills 3 feet apart, the stalks about 8 to 10 inches apart in the row (the rows were in all 166 feet long), was cut after the grain was fully ripe. There were left for this experiment but 142 stalks, and there was obtained from these 41.25 pounds of thoroughly ripened shelled grain, from which, in 1880, a crop was planted and grown. (Upon an acre there would have been 17,424 stalks, in drills 3 feet apart, and the stalks 10 inches apart, and at the rate of yield obtained, there would have been 5,430 pounds of shelled corn, which, at 56 pounds to the bushel, would be 97 bushels, a very remarkable but not unprecedented yield.)

After having had stalks removed for analysis, there yet remained 142 stalks to the 166 feet of row, which yielded at the rate of 69.1 bushels of shelled corn to the acre.

These 142 stalks were worked for sugar, and the results were:

	Pounds.
Weight of stalks with leaves	222
Weight of leaves	67
Weight of stripped stalks	155
Juice expressed by mill	70
Per cent of juice to stripped stalks	45.16
Specific gravity of juice	1.070
Syrup made	9.5
Per cent of syrup from juice	13.57

Analysis of Syrup.

	Per cent.
Sucrose	65.70
Glucose	13.07

Of this syrup, 53 per cent was obtained as excellent sugar, and 47 per cent as molasses, which afterward gave a second crop of sugar crystals. This result is equal to a yield of 618 pounds of sugar per acre from first crystallization, and 44 gallons of molasses, besides the crop of ripened grain.

In 1881, owing to the drought, a less yield of ripe grain was obtained than in the last experiment, only 48.4 bushels per acre—but the available sugar in the juices gave a yield of 366 pounds of sugar per acre.

While, therefore, the yield of sugar and syrup from maize is less than that from sorghum, it would appear worth while to pursue these investigations, since the results already obtained show the presence, in the stalks of our common varieties of maize, of an amount of sugar far more valuable than is the grain, and which may be readily secured by the same processes employed in the extraction of sugar from the sugar-cane and sorghum.

The general practice of drying the corn upon the stalk would, of course, have to be modified, in case the stalks were to be used for syrup or sugar production; but there is no doubt that means could readily be devised to accomplish this result.

In the case of sweet corn, which is plucked while immature, there is no reason why the stalks should not be thus used; and, since they retain their content of sugar for weeks after the ears have been removed, there is ample time to utilize what is largely a refuse material. Besides, if it shall be found that the profits of canning may be enhanced by this additional product from the stalks, there is reason to believe that this business, already so extensive in certain sections of the country, might be greatly enlarged, and, by exportation of canned corn, increase a demand for the crop, which even now occupies fully 38 per cent of all the cultivated land of the United States. In 1880 over sixty-two million acres of land were in maize. Although it may be premature to declare the utilization of any portion of this enormous acreage of stalks for sugar and syrup production, it is true that at present they are, for the most part, practically wasted. It is also, beyond question, true that they contain, at the very least, twice as much sugar as would supply the United States. That the economical production of this vast amount of sugar is only a question of time is probable. It yet remains a promising field for future investigation.

Per Cent of Leaves and Stripped Stalks of Maize.

The relative amount of leaves and tops, as compared with the stripped stalks of maize, is as the average of several hundred stalks of nine varieties: 59.8 per cent stripped stalks, 40.2 per cent leaves and tops.

COMPARISON OF SORGHUM AND MAIZE JUICES.

The following table has been prepared from the results of analyses, made in 1880 and 1881, of 38 varieties of sorghum and 9 varieties of maize, and comprise some thousands of analyses.

The average results of the analyses of all those juices falling within the specific gravities given are included, and we have those between 1014 and 1073 both for sorghum, of which there were, in 1881, 722 analyses made, and of maize, of which there were 202. So, too, in 1880, between specific gravity 1019 and 1073, there were 2133 analyses made of sorghum and 188 of maize juices.

The analyses also are averaged of those juices between specific gravity 1050 and 1070, of both sorghum and maize, for 1880 and 1881; since these specific gravities include those juices generally worked from syrup and sugar.

There are also given the average results of those sorghum juices which were of greater specific gravity than those of maize, viz.: In 1880, from 1070 to 1090; and in 1881, from 1070 to 1095. And, finally, the general average for both years, of sorghum and maize juices between 1019 and 1073, and between 1050 and 1070.

Besides the average analyses of these juices, the per cents of available sugar, total sugars, total solids, sucrose in total sugars, and in total solids, is given. The table represents a very large number of analyses, over 3,000, and a large number of varieties, 38 of sorghum and 9 of maize; also the results of two seasons very unlike in climatic conditions, as will be seen on page 148. This conclusion, therefore, may be regarded as clearly established, which to many will appear most surprising, viz.: In every case where two juices of the same specific gravity are taken, the one of sorghum and the other of maize stalks, it will be found that, in every respect, that from maize is superior: First, in the content of sugar; second, in the per cent of sucrose in the total sugar, through a less quantity of glucose; and, third, in the per cent of sucrose in the total solids. In other words, the maize juice is the purer, and, by consulting the table, it will be seen that it is very much more pure. For example: As the result of the analyses of 1880 and 1881, the juices of maize, of specific gravity between 1050 and 1070, contained 12.11 per cent on an average of total sugars, and

10.41 per cent was sucrose, or 86 per cent of the total sugars. The sorghum juices of this specific gravity averaged 12.28 per cent of total sugars, of which only 9.56 was sucrose, or 77.9 per cent of the total sugars. The per cent of total solids was in each the same, 15.17; but in the maize juices 68.6 per cent, and in the sorghum juices 63 per cent, of the total solids was sucrose. The average available sugar was, in the maize juices, 5.65 per cent, and in the sorghum juices 3.95 per cent of the juice.

It is, however, to be remembered, that at present sorghum is far more valuable for purposes of sugar or syrup production, owing to the following reasons:

1. Sorghum is far more constant in its composition, as well as uniform, while maize appears to vary greatly, even specimens of the same variety taken at the same time from the same field.

2. Sorghum reaches ultimately a much higher content of sugar than maize, as in 1880 there were 778 analyses made of juices having a specific gravity between 1070 and 1090, and averaging 14.26 per cent of sucrose, of which 8.66 per cent was available; and in 1881 there were 485 analyses of juices of specific gravity between 1070 and 1095, averaging 15.85 per cent of sucrose, of which 10.68 per cent was available. At present no such maize juices have been obtained, except at rare intervals.

3. Owing to the habit of the plant in bearing its seed, and the conditions necessary for its complete development, a greater weight of crop can be grown to the acre of sorghum than of maize.

But sugar of excellent quality, and in paying quantity, has been repeatedly secured from the stalks of maize after the seed had thoroughly ripened; and it is by no means beyond reasonable expectation that certain varieties of maize may be found or developed by careful selection, which shall rival the sorghum in its sugar content, and prove to be as constant and uniform as are the best of the sorghums. That we have in maize a plant possessing a marvelous degree of adaptability to the varying conditions of soils, climate, and cultivation, is known to all. In this respect it certainly equals, if it does not surpass, the sorghum, which has through centuries of cultivation produced varieties so widely different as to have perplexed the botanist. But we have large groups of the sorghum family poorer in sugar than any of the varieties of maize thus far examined, and there is reason to hope that when investigations shall have taken the place of ridicule and dogmatic assertion, a plant so plastic in the hands of the cultivator as maize has shown itself, may be developed into varieties equal to any at the present known as producers of grain, and at the same

time more valuable as sources of sugar. Such a result appears clearly foreshadowed in the work already done upon this distinctively native cereal Zea mais.

COMPARISON OF JUICES OF SORGHUM AND MAIZE.

Year.		Specific gravity.	Beaumé.	Per cent sucrose.	Per cent glucose.	Per cent solids.	Per cent available sugar.	Per cent total sugars.	Per cent sucrose in total sugars.	Per cent total solids.	Per cent sucrose in total solids.	Number of analyses.	Number of varieties.
1881	Sorghum.......	1014-73	2°-9° 9	5 03	2 99	3 00	— 96	8 02	62.7	11 02	45 6	.722	38
1881	Maize	1014-73	2°-9° 9	5 83	2.54	2.53	.76	8 37	69.7	10 90	53.5	202	8
1881	Sorghum........	1050-70	7°-9° 5	9 45	2.77	3 15	3 53	12 22	77 3	15 37	61 5	336	38
1881	Maize....	1050-70	7°-9' 5	10 53	2 25	2 47	5 81	12 78	82.4	15 25	71 0	42	8
1881	Sorghum.......	1070-95	9° 5-12° 5	15 85	1 55	3 62	10 68	17 40	91 1	21.02	75 4	485	38
1881	Sorghum........	1019-73	2° 6-0°.0	5.49	3 11	3.07	– 69	8 60	63.8	11 67	47 0	694	38
1881	Maize.....	1019-73	2°.6-9° 9	6.38	2.64	2.60	1.14	9 02	70.7	11 62	54.9	188	8
1880	Sorghum........	1019.73	2° 6-9°.9	6 37	3.27	2.22	.88	9 64	66 1	11 86	53 7	2133	38.
1880	Maize...........	1019-73	2° 6-9° 9	7.47	1 19	2 89	3 39	8 66	86 3	11 55	64 7	188	9
1880	Sorghum	1019-79	2°.6-10° 5	7.10	3 10	2 36	1.64	10 20	69 6	12 56	56 5	2486	38
1880	Maize..	1019-79	2°.6-10°.5	7 95	1 16	3 10	3.69	9 11	87.3	12 21	65 1	196	9
1880	Sorghum	1050-70	7°-9°.5	9 67	2.67	2 62	4.38	12 31	78 4	14 96	64 6	1351	38
1880	Maize......... ...	1050-70	7°-9° 5	10 29	1 14	3 65	5.50	11 43	90 0	15.08	68 2	114	9
1880	Sorghum........	1070-90	9°.5-12°.	14 26	1.56	4 04	8.66	15.82	90 1	19 86	71 8	778	38
80-81	Sorghum....	1019.73	2°.6-9° 9	5 93	3 19	2 65	09	9.12	65.0	11 77	50 4	2827	38
80-81	Maize...........	1019-73	2° 6-9° 9	6 93	1 92	2 75	2.26	8 85	78.3	11.60	59.7	376	9
80-81	Sorghum........	1050-70	7°-9° 5	9 56	2.72	2.89	3 95	12.28	77 9	15.17	63 0	1687	38
80-81	Maize........ ...	1050-70	7°-9°.5	10.41	1.70	3.06	5.65	12.11	86.0	15.17	68.6	156	9

The effects of frost upon the sugar in the maize stalk, and of allowing the stalks to remain unworked after having been cut, are in all respects identical with those which have already been fully set forth in the chapters upon sorghum, see pages 154 and 126.

PEARL MILLET.

The following analyses were made of the stalks of this plant, and, as will be seen, the content of sugar was remarkable, after the plant had fully matured—in this resembling the sorghums:

PEARL MILLET.

Date.	Development.	Number of stalks for analysis.	Length of topped stalks, in feet.	Diameter at butts, in feet.	Weight of whole stalk, in pounds.	Weight of stripped stalk, in pounds.	Per cent of water in cane.	Weight of juice, in pounds.	Per cent of juice in stalks.	Specific gravity of juice.	Per cent of solids in juice.	Per cent of glucose in juice.	Per cent of sucrose in juice.	Per cent solids not sugar in juice.
Sept. 10	Stamens still on.	2	5.7	062	1.67	1 12	*	505	30.0	1.035	*	1 6	3.7	....
10	Stamens fallen....	2	6.7	062	1.57	1 04	*	480	30.5	1.034	*	1.6	1.9	....
16	No change in appearance.......	2	5 3	073	2.00	1 02	76 31	.373	18.6	1 049	11 17	.8	7 3	3.07
19	....do..	2	5.1	062	1.78	1.09	76.98	.406	22 8	1.049	11.53	1 5	7.0	3.03
25	Dry tops; suckering.	3	5 7	065	2.50	1.49	72 00	.547	21 5	1.054	11.09	1.1	8 7	1.29
29	....do..	3	6 6	.065	3.00	2 08	75.53	.783	26 1	1.060	11.21	1.2	9.6	.41
Oct. 4	Dry tops; suckers well developed	2	5 1	.056	2 09	.98	67 35	529	25.3	1.061	14.10	1.3	10.1	2.70
14	Leaves dead and yellow..	2	6.1	072	1.85	.97	64 41	377	20 3	1 068	15.30	2 0	11 3	2.00
20	Frost-withered....	2	6 1	.072	1 65	1.06	65 65	560	33 9	1.058	13 15	3.0	6.7	3 45
29	Quite dead	3	5.6	059	1 53	.88	72 54	337	22.0	1.070	16.18	5.4	7 4	3.38
24	Withered	2	5 3	059	1.20	.77	75 77	.302	25.1	1.058	18.14	.5	11.7	5.94

An experiment was made with the juice of pearl millet, with the following results: Stripped stalks taken, 130 pounds. These were passed through an old mill, which only gave 29 pounds of juice, or 22.3 per cent of the weight of stripped stalks. This juice had a specific gravity of 1062, and it gave, upon evaporation, 2 pounds 10 ounces of syrup, or 9 per cent of the weight of juice. This syrup readily crystallized, and gave, in the first lot of sugar, 17½ ounces of sugar, or 42 per cent of the weight of the syrup. The sugar polarized 92°.

Owing to the enormous acreage yield of this plant, it seems worth further investigation as a possible source of sugar.

* Burned.

CHAPTER XIV.

(*a.*) Exhaustion of soil by growing sorghum.
(*d.*) Exhaustion how prevented in growing sorghum.
(*c.*) Average yield of principal crops in each state of United States, from 1868–72, and from 1872–80 compared.
(*d.*) Value of ash constituents of principal crops of United States.
(*e.*) How exhaustion of soils may be prevented by use of fertilizers.

EXHAUSTION OF THE SOIL AND FERTILIZATION OF THE CROP.

In another place, page 395, there is given the amount of mineral matter, or ash, which is removed by an average crop of sorghum. A crop so heavy must, in its seed, stalk, leaves, and roots, make an unusual demand upon the soil, and the analyses of these several portions of the plant confirm the fact, that few of our crops are, in reality, so exhaustive of plant food as is sorghum.

In the face of this fact, which is unquestionable, there is abundant evidence to show that sorghum may be grown for successive years upon the same land with little if any diminution in the yield; also, that it will succeed where many other crops fail, and that, in fact, sorghum, even after a succession of heavy crops, leaves the land in good condition for other crops. These facts are apparently established.

The following, from one of the recent reports of a convention of sorghum growers, will illustrate the erroneous conclusions which have been drawn from these facts:

There is this about it, and it ought to be taken into consideration in studying to diversify our industry, that the wheat crop is a very exhaustive crop for the soil. I can recollect back in the State of New York, where I was born, and where my parents now reside, my father, when I was a boy, used to raise 25 and 30 bushels of wheat to the acre, with no difficulty in obtaining that yield. I was back there last fall, and he has a good farm, one of the best in that section, puts out his little patch of wheat, even now, every year, and, if he gets 8 or 10 bushels to the acre, he thinks he is doing very well; and this has been the history of all wheat counties throughout the state of New York. It is the same in the state of Maryland, Delaware, and portions of Pennsylvania; but, as time has gone on, those fields which have produced this crop have been exhausted of those properties which make wheat, and they are no longer able to produce a paying crop, and manures and fertilizers and phosphates and superphosphates have to be applied, and the yield sometimes hardly pays for the amount paid out for these. That same destructive policy is going on throughout the entire west, and it will not be many years, even within the recollection of some

of these younger men, when a yield of 8 or 10 bushels to the acre will be all that you will obtain from your wheat crop. There is another thing in connection with the sorghum crop, and it is a remarkable thing—it is not an exhaustive crop. It was said to you to-day by Prof. Swenson, and it has been said by professors of chemistry of numerous agricultural colleges, that your sugar and syrup are obtained from the sunshine and the air, and not from the soil. The ash of the sorghum is simply nothing, the amount which it obtains from the earth very small indeed. Some of our farmers believe that sorghum acts upon the soil something like clover, that it is a fertilizer. I have heard, at different sorghum conventions, farmers talking among themselves, and saying that they did not know what crop of grain they could safely plant after a sorghum crop. If they planted oats, or wheat, or barley, it was so productive and grew so rank that it would lodge, and they would have to put some other crop upon it on that account. Here is Seth H. Kenney, who was spoken of by your worthy president this afternoon. He said that for sixteen years sorghum had been raised upon the same field, and the last crop was just as productive as the first that was put upon it, and no fertilizer employed during that time. I think, however, I heard Mr. Kenney say that, a year or two ago, he did apply some fertilizer. Mr. Swartz, who lives in Illinois, near St. Louis, for 12 years has grown a crop upon the same soil without the application of any manure, and he says that every year the juice is purer, and the syrup and the sugar are better from that land. This is a remarkable quality in this crop. It is not going to impoverish your land.

Without questioning any of the interesting facts above stated, as to this remarkable plant, it would be difficult to draw conclusions more erroneous, or ultimately more fatal to successful agriculture.

The fact that the acreage yield of wheat has fallen off in many sections of the country, is beyond question, but it is also true that many crops may be successfully grown upon lands which will not yield a good return in wheat.

Clover, for example, has been long used as a crop preparatory to wheat, and yet clover makes a far greater demand upon the soil than does wheat, as is established by analysis. So, also, sorghum really exhausts the land far more rapidly than wheat or even clover, and yet it may be grown for years upon the same land successfully.

It is also a matter of common experience, that sorghum is capable of withstanding a period of drought, which would be fatal even to the crop which most nearly resembles it, maize (or Indian corn).

We must look further, for the solution of wheat appears contradictory.

The mutual relations of wheat and clover have been thoroughly investigated, and their apparent anomalies fully reconciled. Wheat is a plant of a short period of growth, of a very scanty leafage, and, with mostly surface roots, comparatively limited in amount; while nearly opposite conditions are found in the clover plant, with its abundant

leafage, its prolonged life, and its root system, which enables it to seek supplies of food from the subsoil. It is then obvious, that, with these far greater facilities for securing food, clover, even though requiring far more food from both the atmosphere and the soil than does wheat, is adapted to thrive where the more dainty wheat plants would fail. Not only this, but the clover plant, during its growth, accumulates an enormous amount of plant food from the atmosphere and the soil, which is left in the soil by its roots: these, by their decomposition, being sufficient to supply the limited demands for such food by a future crop, as of wheat. It must not be concluded that such crops as sorghum or clover, because growing where other crops fail, are, therefore, not exhausting crops; for, on the contrary, few crops remove so much plant food from the soil as do these. They must inevitably impoverish the soil sooner or later; and it is, therefore, of supreme importance that correct ideas shall prevail among our sorghum growers, before it is too late, concerning a matter of such fundamental necessity as that of maintaining the fertility of our lands. Indeed, one of the leading motives which should prompt us in our efforts to produce our own sugar is, that this important commodity is wholly derived from the atmosphere, and therefore may be produced in indefinite quantities, and for unlimited time, upon our soil, without in any way decreasing its fertility. On the other hand, it is probable that our soils would become more productive, provided only that care be taken to return to the soil those constituents which, in the seed, bagasse, leaves, and the scums and the sediments of the sugar, will have been removed from the land.

The system pursued at Rio Grande, New Jersey, appears in the highest degree judicious. By means of several hundred swine, the entire crop of seed is consumed upon the plantation, and the bagasse is thrown into the pens to be incorporated with the manure; thus furnishing, for the enrichment of the land, an abundant supply of good fertilizing material. In addition to this, quantities of sea-weed and muck from the adjacent beach are added to the accumulations of the pens. It has been found that the hogs thrive when fed no other food; and the profit derived from this disposition of the seed and bagasse is estimated as sufficient to enable the company to raise and deliver their cane at the mill entirely free of cost: the sugar and syrup obtained from the cane costing only the expense of its manufacture. It is estimated that one acre of seed, with the bagasse, will prove quite sufficient for the production of one hog weighing from 350 to 400 pounds. This estimate appears reasonable, since, as is well known, the sorghum

seed equals in quantity the yield of corn upon the same ground, and chemical analysis shows it to be practically identical in composition with corn. If swine may be fattened without loss upon corn, as is the case, there appears no reason to doubt but that this method of using the seed at Rio Grande may enable them to pay all expenses for their crop of cane. Mr. Joseph Sullivant, of Duncan's Falls, Ohio, made a thorough examination of all available statistics concerning the fattening of swine upon corn, and sums up the evidence as follows:

> I conclude that nine pounds of pork from a bushel of corn, fed in the ear, twelve pounds from raw meal, thirteen and a half pounds from boiled corn, sixteen and a half pounds from cooked meal, is no more than a moderate average, which the feeder may expect to realize from a bushel of corn, under ordinary circumstances of weather, with dry, warm, and clean feeding pens.

The two most important considerations, then, in connection with this new industry, viz., the economical production of sugar and syrup, and the maintenance of the fertility of the land, urge that this practice, followed at Rio Grande, N. J., be imitated, so far as may be, by all entering upon the cultivation and manufacture of sorghum.

The corn crop of 1881 occupied 37 per cent of all the cultivated land in the United States, even including the grass lands, viz., 64,-262,025 acres out of a total of 173,675,409 acres.

During the years 1871 to 1881 inclusive, the total crop of corn produced in the United States was equal to 13,662,965,083 bushels, which at 56 pounds to the bushel is equal to 382,563,022 tons.

The average of 28 analyses of maize gives 1.63 per cent of ash, and of this ash 46.53 per cent is phosphoric acid, and 32.56 per cent is potash.

So that there was removed from the land in the corn crop of those eleven years 6,235,777 tons of mineral matter, of which 2,901,507 tons were phosphoric acid, and 2,030,369 tons were potash. At 12 and 7 cents per pound, the prices respectively in the so-called commercial fertilizers, the value of these two components of the ash of the corn crop for those 11 years was $696,361,680 for the phosphoric acid, and $284,251,660 for the potash, or a total for the two of $980,-613,340.

Now, the total value of the corn crop for those 11 years was $5,-883,068,121, so that the phosphoric acid and potash in this crop were worth at those prices which are paid for those materials $16\frac{2}{3}$ per cent of the total value of the crop. For those same years the average number of bushels per acre of corn was 26, and the average value of the crop per acre was $11.20.

It is hardly probable that, at the present, corn is grown at a profit

much, if any, beyond $16\frac{2}{3}$ per cent, and yet it is beyond question true that at no distant period it will be necessary to resort to fertilizers to maintain the fertility of our lands, as has been so largely done in the Eastern States.

It was in view of these considerations that the present chapter was written, which, at its conclusion, refers to another method by which this exhaustion of the soil could be arrested. It is hardly necessary to say that it was by the introduction of the growth of sorghum instead of corn, by the feeding of the seed of sorghum upon the farm, and by the production of our sugar supply from the stalks, that this exhaustion was to be permanently arrested.

In view of our rapidly increasing population, and in consideration of the fact that the land available for purposes of agriculture will be ocpied within a very short period, as also that the exportation of our agricultural products, especially of the cereals, already enormous in the aggregate, is steadily increasing, the subject of the maintenance of the fertility of our farming lands is one of supreme material importance.

The question whether the past and present productiveness of our soil is to continue indefinitely, or whether sooner or later, through exhaustion of its elements of fertility, diminished crops shall result, is one which ordinary prudence should not postpone for future consideration.

It may, perhaps, be doubted whether as yet we possess sufficient data from the records of our own experience, and in our own country, to enable us to decide this important question; still, we have the accumulated experience of other countries and other ages to guide us as to the probable solution of our own problem.

While upon limited areas of land the fact of exhaustion appears to be pretty well established, it is a matter of some considerable difficulty to establish the fact that exhaustion, more or less in degree, has manifested itself over the whole country. The productiveness of the soil depends upon so many and so varying conditions other than the simple question of a sufficient supply of plant food, that any conclusions drawn from the returns, of a few years even, are liable to error. For example, as we have heard repeatedly reiterated during the past few years, the country has for several years been blessed with almost unprecedented crops, which it would be fully to expect are to be continued in equal abundance during the next decade. As may be seen by any one looking over the agricultural statistics, there appear to be "off years" for certain crops, so that, while the conditions are favorable to some crops, they are not favorable to others.

Again, since the demand upon the soil for plant food varies both qualitatively and quantitatively so widely for different crops, while the

ability o. plants to avail themselves of the supplies of food present in the soil also differs as widely, it therefore happens that, while certain crops suffer a falling off, others may be produced in their original abundance.

In the hope of throwing some light upon this question of exhaustion, I have had recourse to the Annual Reports of the Department of Agriculture since the year 1861. Since then there has been, with but few exceptions, annually published the average acreage yield of our principal crops in the Northern States, and, since 1865, in the Southern States.

These annual average acreage yields of the principal crops have been averaged for each state for the first half of the period, and for the latter half of the period—*i. e.*, for the Northern States, the average acreage yield is given of each crop from 1862 to 1870, inclusive, and from 1871 to 1880, inclusive; and for the Southern States, from 1866 to 1872, inclusive, and from 1873 to 1880, inclusive.

These results are given in the table following; and, of course, covering so long a period of years, and so wide an extent of territory, local or temporary inequalities would tend to disappear, and the general result would probably closely approximate to the truth:

AVERAGE ACREAGE YIELD OF THE PRINCIPAL CROPS IN EACH STATE.

States.	Years.	Corn.	Wheat.	Rye.	Oats.	Barley.	Buckwheat.	Potatoes.	Hay.	Tobacco.
Maine	1862–70	31 05	12.77	15.51	26 51	20 94	33 44	125 6	1801	750
"	1871–80	32 22	13 70	16 15	25.79	20 43	23 29	108 0	1834	....
New Hampshire	1862–70	33.27	14.34	15 46	28 60	23.09	19.69	121 4	2002	510
" "	1871–80	39.98	15.14	16.87	37.00	24 22	19.77	114 2	2004	1353
Vermont	1862–70	36.90	16 33	15.70	34.41	24.69	22.63	139.8	2097	766
"	1871–80	36 57	16 40	17 17	35.31	25 58	21 79	133 5	2136	1246
Massachusetts	1862–70	32 19	16 29	14.82	27.85	21 99	16 88	112 9	2343	1268
"	1871–80	34.75	18.21	15.86	32 33	22.82	14 18	114 8	2256	1524
Rhode Island	1862–7.	29 23	16.94	17.40	32.55	25 18	16 31	99 9	2175	1166
" "	1872–80	30.27	....	14 72	30.10	21 43	....	90 9	2061	. . .
Connecticut	1862–70	31.65	16 84	13 91	31.22	23 69	15.36	104 7	2484	1329
"	1871–80	30 07	16.65	14 66	29 46	22 45	16 54	88 6	2344	1356
New York	1862–70	30 20	14.93	15 17	30.32	22.33	19.77	103 1	2516	918
" "	1871–80	33.13	14 98	14.09	32 71	22 27	18 38	82 5	2372	959
New Jersey.	1862–70	35.95	14.79	14.37	28 94	22.82	18.25	83 3	2873	991
" "	1871–80	37.09	14.54	13 35	28.38	22 87	16 69	80.7	2404	1150
Pennsylvania	1862–70	33.01	13.25	18.88	31.70	22.50	18.09	94.1	2680	979
"	1871–80	36.14	14 13	14 06	32.50	22 16	18 56	86 8	2342	1272
Delaware	1862–70	20.23	11 70	10.63	16.73	19 86	18 62	84 5	2577	440
"	1871–80	24.10	12 71	11.72	21.36	16.55	19 50	83 2	2094	....
Maryland	1862–70	25 82	10.92	12 39	22 09	25 07	19 35	73 9	2632	652
"	1871–80	26.16	12.12	12.43	19.78	17.00	19 95	68.8	2138	682
Virginia	1866–72	19.90	8 51	10 25	17.25	16.60	14 64	66.0	2157	603
"	1873–80	20 26	8 51	9.47	14 16	15.25	15.90	74.0	2412	643
North Carolina	1866–72	13 90	7.11	7 48	13 61	15.85	17.73	87.0	2634	621
" "	1873–80	14.90	7.15	8.52	14.27	16 30	15.70	86.0	2662	530

AVERAGE ACREAGE YIELD, ETC.—*Continued.*

States.	Years.	Corn.	Wheat.	Rye.	Oats.	Barley.	Buckwheat.	Potatoes.	Hay.	Tobacco.
South Carolina	1866–72	9 53	5 91	5 93	9 50	11.41	....	79 0	1943	525
" "	1873–80	9 25	6 92	6.17	13.48	17 00	. .	80 0	2340	497
Georgia	1866–72	14 33	6 71	7.41	12.24	13 55	....	87 0	2563	491
"	1873–80	10 55	7 45	6.42	12 61	13 67	....	73.0	2817	626
Florida	1866–72	11.11	8.97	9.62	14.38	14 20	....	110.5	3225	552
"	1873–80	10 10	....	.	13 28		.		. ..	677
Alabama	1866–72	14 37	7.37	8.20	12 71	12.14	..	76 3	2483	496
"	1873–80	12.85	7 42	8.67	13 71	11.50	....	74 0	2790	580
Mississippi	1866–72	16 11	8 94	8.35	14 74	11 80	. . .	80 0	2471	511
"	1873–80	15 11	8 28	10 40	15 51		. . .	79 0	2910	552
Louisiana	1866–72	19 28	8 54	10 16	17 68	18 00	....	94 0	3040	533
"	1873–80	16 95	. ..		14 26		....	67 0	2600	777
Texas	1868-72	25.57	11.47	15 82	25 15	22.91	. .	111.0	2840	598
"	1873–80	21 37	13 01	15 51	30.15	29 10	.	83 4	2840	744
Arkansas	1866–72	27.28	10 08	13.03	21 43	14 50	15 00	87 0	2857	780
"	1873–80	23.38	8 87	11.88	22 21			89 0	2775	724
Tennessee	1866–72	23.33	7 45	9 51	17.61	20 89	11 90	73 2	2703	718
"	1873–80	25.25	7.55	9 77	17 95	18.42	15 44	78 0	2637	659
West Virginia	1867–73	29 71	10 60	13 18	24 97	17 31	16 48	73 3	2382	674
" "	1874–80	28 21	11 18	10 68	21 85	14 60	17 64	80 0	2360	683
Kentucky	1864–70	29.82	8.81	11 03	21 97	18.49	16.58	72.3	2669	697
"	1871–80	29 39	10 22	11 58	21 65	23 35	17 62	71 3	2528	702
Ohio	1862–70	33 29	11 90	13 46	28 45	23.15	16.21	83 0	2722	808
"	1871–80	36 36	14 39	13 80	29.17	24 29	14.34	83 3	2328	872
Michigan	1862–70	32.68	14 06	15 86	31 50	23.25	17 40	111 8	2738	1057
"	1871–80	33 35	14 99	14 41	31 91	22 78	16.16	86 0	2422	. ...
Indiana	1862–72	33 09	11 72	14 73	24 32	22 86	18 24	81 1	2965	812
"	1871–80	31.58	13 54	14 16	25 76	22 60	15 46	69 4	2530	699
Illinois	1862–70	34.78	13 80	18 24	33 08	26.94	16 37	86 3	3355	867
"	1871–80	29 07	13 47	16 80	30 49	22 64	14.34	75 7	2726	730
Wisconsin	1862–70	37 35	15 72	17 85	37 69	27.77	20 03	116 9	3127	1116
"	1871–80	32 64	12 70	15 56	31 93	26 19	15 52	90 1	2710	988
Minnesota	1862–70	33 07	15 87	19 32	35 58	25 72	18 85	126 6	3230	705
"	1871–80	32 67	14 07	24 35	33 98	26 33	16 02	105 6	2936	..
Iowa	1862–70	34 64	13 73	18 41	34 99	25 78	19 25	103 0	3472	850
"	1871–80	35 14	10 83	16 91	34 62	23 45	17 02	92 9	2858	750
Missouri	1862–70	31 45	14 44	17 04	28 47	24 04	20 47	90 9	3108	829
"	1871–80	29 95	12 23	15 06	27 66	20 30	17 21	76 2	2672	810
Kansas	1862–70	35 33	16 85	22 45	33 30	27 40	21 72	100 0	3474	680
"	1871–80	34 43	13 76	18 28	30 77	21 32	16 00	84 0	2934	640
Nebraska	1864–71	34 60	16 37	20 57	36 28	27 83	22 31	94 8	3500	472
"	1872–80	33 86	12 05	16 11	30 86	22 91	18 25	81 2	2964	....
California	1862–73	37.71	16 88	26 07	33 00	24 66	22 57	100 9	2783	...
"	1874–80	32.85	13 38	16 56	31 40	21.47	21 66	118 0	3008	. ...
Oregon	1869–74	29 96	19 06	28 86	35 01	29 40	22 25	108 0	2960	.....
"	1875–80	26.51	18 10	19 86	36 36	26.85	....	127.0	3280	.....

As will be observed the returns for cotton are unfortunately wanting, owing to the fact that the annual returns for this crop, received by the Department of Agriculture, appear to have been very meager and incomplete.

For convenience of comparison I have prepared the following table, in which the acreage yield of each crop for each state for the latter half—viz., for the Northern States from 1871 to 1880, and for the Southern States from 1873 to 1880—has been calculated to the per cent of the yield per acre of the several crops during the first half. It will thus appear, by a glance at this table, the gain or loss per cent

which each state has made in each crop. For example, the average acreage yield of corn in the State of Maine was 3.7 per cent greater from 1871 to 1880, inclusive, than it was from 1862 to 1870, inclusive; while of wheat it was 7.2 per cent greater. Again, Connecticut fell off 5 per cent in its acreage yield of corn during the latter half.

PERCENTAGE YIELD OF EACH CROP DURING LAST PERIOD, THE FIRST PERIOD BEING 100.

States.	Corn.	Wheat.	Rye.	Oats.	Barley.	Buckwheat.	Potatoes.	Hay.	Tobacco.
Maine	103.7	107.2	104.1	97.2	97.5	99.3	85.9	101.2	*
New Hampshire	120.1	105.5	109.1	129.3	104.8	100.4	94.0	100.0	265.2
Vermont	99.1	100.4	109.3	102.6	103.6	96.2	95.4	101.8	162.6
Massachusetts	107.9	111.1	106.1	115.7	103.7	84.0	92.8	96.2	120.2
Rhode Island	103.5	*	84.5	92.4	85.1	*	90.9	94.8	*
Connecticut	95.0	98.8	105.3	94.3	94.7	107.6	84.6	94.3	102.0
New York	109.7	100.3	92.8	107.8	99.7	92.9	80.0	94.2	104.4
New Jersey	103.1	98.3	92.9	98.0	100.2	92.9	96.7	83.6	116.0
Pennsylvania	109.4	106.6	107.0	102.5	98.4	102.5	92.2	88.2	129.9
Delaware	119.1	108.6	110.2	127.6	83.3	104.6	98.4	81.2	*
Maryland	101.3	110.9	100.3	89.5	67.8	103.1	93.2	80.8	104.6
Virginia	101.1	100.0	92.3	82.0	91.8	108.6	112.1	111.8	106.6
North Carolina	107.1	100.5	113.9	104.8	102.8	88.5	98.8	101.0	85.3
South Carolina	97.0	117.0	104.0	141.8	148.9	*	101.2	120.4	94.6
Georgia	73.6	111.0	86.6	103.0	100.9	*	83.9	109.9	127.4
Florida	90.9	*	*	92.3	*	*	*	*	122.6
Alabama	89.2	100.6	105.7	107.8	94.7	*	96.8	112.3	116.9
Mississippi	93.7	92.1	124.5	105.2	*	*	98.7	117.7	108.0
Louisiana	87.9	*	*	80.6	*	*	71.2	85.5	145.7
Texas	84.2	113.4	98.0	119.8	122.2	*	75.0	100.0	124.4
Arkansas	85.7	87.9	91.1	103.6	*	*	102.3	97.1	92.8
Tennessee	108.2	101.3	102.7	101.9	88.1	129.7	106.5	97.6	91.8
West Virginia	95.0	105.5	81.0	87.4	84.[illegible]	107.0	109.1	99.1	101.3
Kentucky	98.5	116.0	105.0	98.4	126.3	106.3	98.7	94.7	100.7
Ohio	109.2	120.9	102.5	102.5	104.9	89.0	100.4	85.5	107.9
Michigan	102.0	106.6	90.8	101.9	97.9	92.8	76.9	88.5	*
Indiana	95.4	115.9	96.1	105.9	98.8	84.7	85.6	85.3	86.2
Illinois	83.5	97.6	92.1	92.1	84.0	87.6	87.7	81.7	84.1
Wisconsin	87.3	80.7	87.1	92.6	94.3	77.4	77.0	86.6	88.5
Minnesota	98.7	88.6	126.0	95.5	102.3	84.9	83.4	90.8	*
Iowa	101.4	78.8	91.8	98.8	90.9	88.4	90.1	82.3	89.4
Missouri	95.2	84.7	88.9	97.1	84.4	84.0	83.9	85.9	97.7
Kansas	97.6	81.6	81.4	92.4	77.8	73.6	84.0	84.4	94.0
Nebraska	97.9	73.6	78.3	85.1	82.4	81.8	88.9	84.7	*
California	87.0	79.2	63.5	95.1	87.0	85.9	116.9	108.0	*
Oregon	88.5	95.0	68.8	103.8	91.3	*	117.6	110.8	*
Average	98.0	99.9	96.9	101.3	96.7	94.8	92.9	95.4	†107.6

It will be seen that the average percentages for all the states is, with the exception of those for wheat, oats, and tobacco, less than 100, but these averages must not be taken as representing the relative production for the country at large; since a slight decrease in those States of great productive areas would more than counterbalance a large increase in several of the smaller states, and *vice versa.*

* Reports not given for one or both series of years.

† New Hampshire's per cent, being so entirely disproportioned, is omitted in taking the average for tobacco.

The two tables given must be studied together, since many of the states showing large percentage increase are at present very low in their actual acreage yield, in comparison with other states which have declined in their percentage yield. For example, while South Carolina shows an increase of 17 per cent in her acreage yield of wheat, and Connecticut a slight decrease, yet the actual acreage yield of wheat during the past few years in Connecticut is about two and one-half times greater than in South Carolina.

For the purpose of showing which of the states are actually producing less than the average yield of the whole country, the average acreage yield of the principal crops in the United States is here given:

AVERAGE ACREAGE YIELD OF UNITED STATES IN 1880.

Corn	27.6	bushels.	Buckwheat	17.7	bushels.
Wheat	13.1	"	Potatoes	91 0	"
Rye	13 9	"	Tobacco	740	pounds.
Oats	25.8	"	Hay	2,460	"
Barley	24.5	"	Cotton	184.5	"

Of the 36 states given upon the table, the production is as follows:

Corn	22	above the	average and	14	below.
Wheat	18	"	"	18	"
Rye	20	"	"	16	"
Oats	20	"	"	16	"
Barley	7	"	"	29	"
Buckwheat	10	"	"	19	"
Potatoes	10	"	"	26	"
Tobacco	17	"	"	17	"
Hay	20	"	"	16	"

In the following table I have taken the average acreage yield for the United States of the principal crops in 1880 as a basis, and calculated the percentage yield of these crops in the several states in the year 1879.

For example, Maine produced per acre, in 1879, 16.7 per cent more corn and 4.6 per cent more wheat than the average acreage yield of these crops in the United States; while South Carolina produced per acre but 33.5 per cent of the average acreage yield of corn in the United States, and but 52.9 per cent of the average acreage yield of wheat in the United States. I have selected only those crops of general cultivation throughout the country, and which are most largely produced. The aggregate value of the corn, wheat, oat, potato, and hay crops amounts to $1,608,007,820, equal to 83.7 per cent of the value of all our leading agricultural crops.

PERCENTAGE YIELD OF EACH CROP IN EACH STATE OF THE AVERAGE CROP THROUGHOUT THE UNITED STATES.

	Corn.	Wheat.	Oats.	Potatoes.	Hay.
Maine	116.7	104.6	100.0	118 7	74.6
New Hampshire	141 9	115.6	143.4	125.5	81.5
Vermont	132.5	125.2	136 9	146.7	86 9
Massachusetts	125 9	139.0	125.3	115 2	91.7
Rhode Island	109 6	....	116 7	99.9	83 8
Connecticut	109.0	127.1	114.1	97.3	95.3
New York	120 0	114 3	126.8	90 7	96 4
New Jersey	134 4	111.0	120 0	88.7	97 7
Pennsylvania	130 9	107.9	126 0	95.3	95 2
Delaware	87 3	97 0	82.8	91 5	85 1
Maryland	94 8	92 5	76.7	75 6	86 9
Virginia	73.4	65 0	54 5	81 3	98.0
North Carolina	54 0	54 6	55.3	94.5	108 2
South Carolina	33 5	52 9	52.2	87 9	95.1
Georgia	38 2	56.9	48.9	80.2	114 5
Florida	36 6	...	51 5	....	....
Alabama	46 6	56 6	53.1	81 3	113.4
Mississippi	54.7	63.2	60 1	86 8	118.3
Louisiana	61 4	....	55 3	73 6	105.7
Texas	77.4	99.3	116 9	91.6	115.4
Arkansas	84 7	67.7	86 0	97.8	112.8
Tennessee	91 5	57.6	65 7	85 7	107.2
West Virginia	102.2	85.3	84 7	87.9	95.9
Kentucky	106 5	78.0	83.9	78 4	102.8
Ohio	131.7	109 8	113 1	91 5	94.6
Michigan	120 8	114.4	123 7	91.5	98 5
Indiana	114 4	103.3	99 5	76.3	102 8
Illinois	105 3	102.8	118.2	83.2	110.8
Wisconsin	118.3	96.9	135.4	99.0	110.2
Minnesota	118 4	107.4	131.7	116.0	119.3
Iowa	127.3	82 7	134.2	102.1	112.1
Missouri	108.5	93 4	107.2	83.7	108.6
Kansas	124.7	105 0	119.3	92 3	119.3
Nebraska	122.7	92.0	119.2	92.5	120.5
California	119 0	102.1	121.7	129.7	122.3
Oregon	96.1	138 2	140.9	139.6	133.3

If, however, we limit our attention to the two most important cereals, wheat and corn, the latter in 1875 occupying 36.7 per cent, and the former 22.5 per cent of the entire acreage of our farming lands, and the value of these two cereals being equal to 61.3 per cent of all our principal agricultural crops, the conclusions may more clearly appear, and will fairly apply to the remainder of the crops produced.

It is to be remembered that the years from 1875 to 1880, inclusive, were years of very great productiveness for corn, while those from 1877 to 1880, inclusive, were equally so for wheat.

This will appear from the fact, that, while from 1863 to 1874, inclusive, the average acreage yield for corn in the United States was 27.04 bushels, it was, from 1875 to 1880, inclusive, 27.63 bushels, an increase of 2.18 per cent; and while, from 1863 to 1876, inclusive, the average acreage yield of wheat in the United States was 11.91 bushels, it was, from 1877 to 1880, inclusive, 13.48 bushels, an increase of 13.18 per cent.

The above would certainly appear to indicate other than any ex-

haustion; but may not this increased yield during these later years have been owing to the occurrence of other favorable conditions, the continuance of which for the future we may not safely predict?

If, as we have done with the several states, we calculate the average acreage yield of wheat and corn throughout the country for the first and last half of this period, we shall find that, previous to these later years of unusual production, the averages had fallen so low as to almost overcome this increase in the wheat, and to more than do so in the case of the corn.

AVERAGE ACREAGE YIELD FOR UNITED STATES.

	Bushels.
Wheat—1863 to 1871, inclusive, equals	12.06
" 1872 to 1880, inclusive, equals	12.47
Corn — 1863 to 1871, inclusive, equals	27.69
" 1872 to 1880, inclusive, equals	26.78

The increase in wheat, though including these four years of unusual production, is only 3.4 per cent; while the decrease in the yield of corn, though including the past six years of good crops, amounts to 3.3 per cent.

For the purpose of studying this matter more thoroughly, as also for the purpose of throwing some light upon these results, I have grouped the several states as follows, and have calculated the above results for the several groups.

1st. The New England and Middle States, viz.: Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, Pennsylvania, New Jersey, Delaware, Maryland.

2nd. The South Atlantic and Gulf States, viz.: Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Texas.

3rd. The Central States, viz.: Ohio, Michigan, Indiana, Illinois, Kentucky, Tennessee, Missouri, Arkansas.

4th. The North-western and Western States, viz.: Wisconsin, Minnesota, Iowa, Kansas, Nebraska, California, Oregon.

In 1879 there was produced in the United States 1,547,901,790 bushels corn, valued at $580,486,217; 448,756,630 bushels wheat, valued at $497,756,630.

Of these aggregates, there was produced in each of the several sections of country, classified, as follows:

	Bushels of corn produced.	Value.	Per cent of total product.	Per cent of total value.	Bushels wheat produced.	Value.	Per cent of total product.	Per cent of total value.
New Engl'd and Middle States.	104,117,140	$59,960,715	6.7	10.3	44,045,460	$59,999,107	9 8	12.1
North Atlantic and Gulf States	181,333,950	125,028,392	11 7	21 6	26,558,300	32,938,829	5.9	6 6
Central States.	863,746,700	289,070,364	55.8	49 8	201,691,860	226,521,303	44.9	45.6
Northwes'n and Western States	395,953,000	103,950,846	25.6	17.9	159,561,010	156,656,903	35.5	32 1
	1,545,150,790	$578,010,317	99.8	99.6	431,856,630	$476,116,142	96.1	96.4
In territories and states not included in above	2,751,000	2,475,900	.2	.4	16,900,000	20,914,000	3 9	3 6
	1,547,901,790	$580,486,217	100.0	100 0	448,756,630	$497,030,142	100.0	100 0

The average acreage yield of these several sections for the first and later half of the period during which reports are given, and the average percentage yield for the later half of the period, the first half being 100, is as follows:

	Corn—Average yield in bushels.		Wheat—Average yield in bushels.		Corn. Per cent yield last half.	Wheat. Per cent yield last half.
	1st half.	2nd half.	1st half.	2nd half.		
New England and Middle States.	30 86	32 77	14.46	14.86	106 5	104.8
South Atlantic and Gulf States...	17 38	15 96	8 33	8 74	92.0	105 0
Central States.	30 72	29.79	11 53	11.91	97.2	103.9
Northwestern and Western States	34.67	32 59	16.36	13.56	94.1	82 5

If, now, we take the average acreage yield of these two crops in 1879 as a basis, and the reported prices for that crop, we may readily estimate in bushels and money the gain or loss to these several sections in one year, in having maintained or fallen short of the average production of the first half of the period under consideration.

This result will be found as follows:

NEW ENGLAND AND MIDDLE STATES.

6 5 per cent corn=	6,354,564 bushels.	Gain.
6 5 " " =	$3,659,574	Gain.
4 8 " wheat=	2,017.349 bushels.	Gain.
4.8 " " =	$2,748,051	Gain.

SOUTH ATLANTIC AND GULF STATES.

8	per cent corn=	15,768,170 bushels.	Loss.
8	" "	=$10,872,034	Loss.
5	" wheat=	1,264,681 bushels.	Gain.
5	" "	= $1,568,516	Gain.

CENTRAL STATES.

2.8	per cent corn=	24,881,592 bushels.	Loss.
2.8	" "	= $8,327.130	Loss.
3 9	" wheat=	7,570,724 bushels.	Gain.
3.9	" "	= $8,502,725	Gain.

NORTH-WESTERN AND WESTERN STATES.

5 9	per cent corn=	24.825.959 bushels.	Loss.
5.9	" "	= $6,517,641	Loss.
17 5	" wheat=	33,846,294 bushels.	Loss.
17 5	" "	=$33,230,252	Loss.

From the above it appears that the total gain was $16,478,866, and the total loss $58,947,057, or a total net loss of $42,568,191.

It will, of course, be understood that owing to the different acreages of the several states thus grouped together, as also the fact that their percentages of loss or gain are unlike, the above results are obviously, at best, but approximately true. It would be necessary to consider each state by itself, to learn the exact state of facts existing relative to the production of that state; but each for himself may readily make such calculation.

I have, however, selected those states the production of which is very large of these two cereals, and we will consider them somewhat in detail.

The states selected produce an aggregate of over 70 per cent of our wheat and corn, and are, moreover, those states whose production is so largely in excess of their consumption, that it is from their surplus that we derive our large supply for exportation.

It seems proper, then, to consider the past and present production of these states with unusual care. Those selected are Ohio, Indiana, Illinois, Iowa, Missouri, Kansas, Nebraska, Wisconsin, Minnesota, California.

	Bushels corn, 1879.	Bushels wheat, 1879.	Corn, bushels. 1st half	Corn, bushels. 2nd half.	Wheat, bushels. 1st half.	Wheat, bushels. 2nd half.	Corn, per cent. Last half.	Wheat, per cent. Last half.
Ohio.	105,686,000	36,591,750	33 29	36.36	11 90	14 39	109 2	120 9
Indiana...	134,920,500	43,709,960	33 09	31 58	11 72	13 54	95 4	115 9
Illinois	312.221,000	44,896,830	34 78	29.07	13 80	13 47	83 5	97.6
Iowa	185,189,200	32,786,880	34 64	35.14	13.73	10 83	101 4	78 8
Missouri........	141,939,400	26,801,600	31.45	29 95	14 44	12 23	95.2	84.7
Kansas	89,720,400	18.079,500	35 33	34 43	16 85	13 76	97 6	81 6
Nebraska...	62,459,400	13,043,590	34 60	33 86	16 37	12 05	97 9	73 6
Wisconsin..	39,912,600	20,565,720	37.35	32 64	15 72	12 70	87 3	80 7
Minnesota.	15,715,000	31,886,520	33 07	32.67	15 87	14 07	98.7	88 6
California.......	2,814,000	35,000,000	37 71	32 85	16 88	13.38	87 0	79 2
	1,090,577,500	323,372,350						

The above states give an aggregate yield of corn equal to 70 per cent, and of wheat equal to 72 per cent, of the total yield of the United States.

The aggregate value of the corn is equal to 55.7 per cent, and of the wheat to 64.7 per cent, of the entire crops of these two cereals in the United States.

From the above data, we find that the gain or loss in bushels of corn or wheat, and in value, calculated at the average prices for these crops in these several states, is as follows:

	Bush. corn. Loss.	Bush. corn. Gain.	Bush. wheat. Loss.	Bush. wheat. Gain.
Ohio	....	9,723,112	....	7,647,676
Indiana	6,206,343	....	....	6,885,820
Illinois	51,516,465	....	1,077,524	....
Iowa	....	2,592,649	6,950,819	....
Missouri	6,813,091	....	4,100,645	....
Kansas	2,153,290	....	3,328,468	....
Nebraska	1,311,647	....	3,443,508	....
Wisconsin	5,068,900	....	3,969,184	....
Minnesota	204,295	....	3,635,063	....
California	36,582	....	7,280,000	....
	73,310,613	12,315,761	33,785,211	14,533,496

	Value corn. Loss.	Value corn. Gain.	Value wheat. Loss.	Value wheat. Gain.
Ohio	....	$3,792,014	....	$9,177,211
Indiana	$2,110,157	....	....	8,131,364
Illinois	15,970,104	....	$1,152,951	....
Iowa	....	622,236	6,394,753	....
Missouri	1,703,273	....	4,141,651	....
Kansas	581,388	....	2,962,337	....
Nebraska	275,446	....	2,892,547	....
Wisconsin	1,976,871	....	4,127,951	....
Minnesota	55,160	....	3,416,960	....
California	288,998	....	8,954,400	....
	$22,961,397	$4,414,250	$34,043,550	$17,308,575

In nearly all of these states there is a loss of both corn and wheat, amounting in the aggregate to a net loss of 60,994,852 bushels of corn, and 19,251,715 bushels of wheat, with a value for the corn of $18,547,-147, and for the wheat of $16,734,975, or a total loss for both of $35,282,122.

This deficiency and annual loss, it will be understood, represents the diminished yield of corn and wheat of these states, through failure on the part of the soil, from whatever cause or causes, to maintain the same acreage yield which it had averaged from 1862 to 1870, inclusive.

Despite the very great inequalities of productiveness in the several sections of the country, which are doubtless largely due to inherent

and original differences in the character of the soil, to climatic conditions favorable or unfavorable to agricultural production, and in part also to better agricultural methods obtaining in some sections, it is true that over large and most productive areas of our country, the fertility of the soil has suffered appreciable diminution.

If we contrast the New England and Middle States, for example, with those of the Central or the North-western and Western States, we shall fi: d, although the former were but a few years ago surpassed in productiveness by the latter, that, during the short period of fifteen or twenty years, the yield of the latter has fallen off, while that of the New England and Middle States has increased, so that at present the acreage yield of these New England and Middle States surpasses that North-western and Western States and of the Central States.

This is the more remarkable, in view of the fact that these same lands which have so increased in productiveness have been under the plow for at least a century longer than those of the West.

This result is probably due largely to inherent differences in the soils of the several sections. The rocks of New England, which by their gradual disintegration have formed these lands, will probably be found richer in the mineral constituents of plant food than the rocks of the West. But it is beyond question that the early settlers upon these western lands found them rich in the elements of plant food, which through ages had accumulated.

The continued cropping and wasteful methods which characterized the early years of western agriculture appear, however, to have partly, at least, exhausted these accumulated stores of food, as evidenced by diminished crops.

As is well known, the cereals require for their development large quantities, comparatively, of potash and phosphoric acid, and these two mineral constituents exist in comparatively very small quantities in the rocks or in the soil derived from them. It follows, therefore, that they would naturally be soonest removed from the soil by continual cropping, and, as is known, this removal has necessitated the restoration to the soil of these constituents through the application of products containing them.

The so-called commercial fertilizers which have within the past few years been manufactured and sold in the country, especially in the New England and Atlantic States, are chiefly valuable for these two constituents.

If we take as a basis for our calculation the returns for 1879, we may readily determine the amount of these important mineral constituents which is annually taken from our soil by these crops.

In the following table this is shown, and the results are in every case an average of a very large number of separate analyses, by different chemists often, and of samples of the crop grown in different sections and different years, so that there can be little doubt but that the results are very near the exact truth.

The aggregate amount of our principal crops is 106,889,390 tons, and the total mineral matter present in this crop equals 3,707,223 tons, and of this mineral matter or ash there are 1,301,224 tons of potash and 679,901 tons of phosphoric acid. In other words, 53.4 per cent of the total mineral matter necessary for the production of our crop of 1879 (and the same is practically true of every other year) was composed of these two constituents, phosphoric acid and potash, which, in commercial fertilizers, agricultural chemists have agreed are worth respectively 12 and 7 cents per pound.

In the matter of fixing these prices, it must be understood that the chemists have no more to do than in fixing the price of flour or nails, or any other marketable commodity. They simply declare, from the composition and price of such fertilizing materials as are found in the market, that, in certain forms and in certain markets, these constituents may be obtained at such prices.

CROPS OF THE UNITED STATES OF AMERICA, 1879.

		Pounds to bushel.	Tons of crop.	No. of analyses.	Average per cent ash.	Average per cent potash in ash.	Average per cent phosphoric acid in ash.	Tons ash in crop.	Tons potash in crop.	Tons phosphoric acid in crop.
Corn .... bu..	1,547,901,790	56	43,341,250	36	1 67	27.8	46.8	737,799	201,216	338,738
Wheat......... do	448,756,630	60	13,462,699	94	2.00	31.3	46 1	264,254	82,712	121,821
Oats .... do.	363,761,320	32	5.820,181	21	3 30	15 6	21 3	192,066	29,862	40,910
Rye .... do..	23,639,460	56	661,905	21	2.00	28 8	45 6	13,238	3,813	6,037
Barley .... do .	40,283,100	48	966,794	43	2 50	21.2	32.8	24,170	5,124	7,928
Buckwheat ... do..	13,140,000	48	315,360	[illegible]	1.60	14.8	48.4	5,046	749	2,442
Potatoes....... do..	181,626,400	60	5,448,792	39	.41	60.9	18.3	22,340	13,605	4,088
Tobacco........ lbs	391,278,350	..	195,639	13	20 80	17.3	8.1	40,693	7,040	3,296
Hay........ tons	35,493,000	..	35,493,000	34	6.74	39.8	6.4	2,392,228	952,107	153,102
Cotton .... lbs..	2,367,540,900	..	1,183,770	.	1 30	32.5	10.0	15,389	4,996	1,539
			106,889,390					3,707,223	1,301,224	679,901

In the following table, the value of the potash and phosphoric acid in the several crops has been calculated, and for the purpose of comparison the value of the several crops is given:

VALUE OF POTASH AND PHOSPHORIC ACID IN THE CROPS OF UNITED STATES IN 1879.

	Value of potash in crop.	Value of phosphoric acid in crop.	Total value of potash and phosphoric acid in crop.	Total market value of crop.	Per cent of potash and phosphoric acid to value of crop.
Corn	$24,170,240	$76,297,120	$100,467,360	$580,486,217	17.3
Wheat	11,579,680	29,237,040	40,816,720	497,030,142	8.2
Oats	4,180,680	9,818,400	13,999,080	120,533,294	11.7
Rye	533,820	1,448,880	1,982,700	15,507,431	12.8
Barley	717,360	1,902,700	2,620,060	23,714,444	11.1
Buckwheat	104,860	586,080	690,940	7,856,191	8.8
Potatoes	1,904,700	976,120	2,880,820	79,153,673	3.6
Tobacco	985,600	791,040	1,776,640	22,727,524	7.8
Hay	133,294,980	36,744,480	170,039,460	330,804,494	51.5
Cotton	699,440	369,360	1,068,800	242,140,987	.4
	$178,171,360	$158,171,220	$336,342,580	$1,919,954,397	17.5

It will be seen that the total value of potash present in the crops is equal to $178,171,360, and of the phosphoric acid to $158,171,220, or together reaching the enormous aggregate of $336,342,580, equal, as will be seen, to 17.5 per cent of the entire value of the crops.

There is also given in the table the value of the potash and phosphoric acid present in each crop, as compared with the market value of the crop, and it will be observed that in this respect there are great differences between the several crops. For example, while the potash and phosphoric acid in a bushel of corn is worth 17.3 per cent of the average market value of the corn, these same two constituents in a bushel of wheat are worth only 8.2 per cent of the average market value of the wheat. This result is due to the greater price which the wheat brings in the market as compared with corn; for the bushel of wheat contains 9.1 cents worth of these two constituents, while a bushel of corn contains only 6.5 cents worth.

The small percentage value of these present in the cotton crop is of course due to the fact that this crop is composed almost wholly of atmospheric constituents, and, so far as the fiber is concerned, makes almost no demand upon the soil for its production.

The small percentage value in the potato crop is likely to be misleading It is, of course, because so large a percentage of this tuber is composed of water (some 90 per cent). But, owing to the very great acreage yield of this crop on good land, the actual amount of potash

and phosphoric acid removed is in reality very great, and, as is well known, this crop is, especially as regards potash, a very exhausting crop.

The hay crop, from every consideration, deserves especial attention, occupying as it does so large a portion of our cultivated land (19 per cent), constituting one-third the weight of the entire aggregate of our crops, and removing annually from our lands an amount of potash and phosphoric acid almost exactly equal to the amount removed by all the other crops combined. Its discussion is of the greatest importance.

Owing to its comparatively cheap production, it is sold at a price incomparably less than any other crop, and yet, as will be seen by reference to the analysis given, which represents the average of 34 of our native American grasses, the demand it makes upon the soil is very great. The potash and phosphoric acid present in its ash is, at the prices we have given, equal to 51.5 per cent of the average selling price of the hay itself.

Fed to the animal, practically all of these two constituents are returned to the manure pile; since in the animal economy but a trifling amount of potash is needed, and only so much of phosphoric acid as will suffice for the production of the bones of the growing animal.

It follows, then, that the manure obtained from the feeding of a ton of hay, having an average composition such as those analyzed, contains an amount of potash and phosphoric acid which, at the prices given, is equal to a little more than half the average selling price of hay in the United States, which was in 1879 given at $9.32. This will be readily seen to be true, for 2,000 pounds hay with 6.74 per cent of ash would contain 134.8 pounds of ash. Of this ash 39.8 per cent is potash, or 53.7 pounds; and 6.4 per cent is phosphoric acid, or 8.6 pounds. Now, 53.7 pounds at 7 cents equals $3.76, and 8.6 pounds at 12 cents equals $1.03, or together $4.79, which equals 51.4 per cent of $9.32, the cost of the hay.

What has been said about the feeding of hay to the animal is equally true of the cereals and other feeding crops. Unlike the vegetable world, the animal demands little mineral food, mainly phosphoric acid and lime, which comprises the ash obtained by the cremation of the animal.

We have, then, obviously one solution as to the important question: "How shall exhaustion of our lands be prevented?" The answer the above facts force upon us is: increase so far as possible the home consumption of our agricultural products, and carefully preserve and return to our lands such portions of those products as are either not fed to the animal, or, if fed, are not assimilated.

None need to be reminded that this practice has been repeatedly urged upon the farmer, and, indeed, thousands of practical illustrations abound proving that profitable agriculture and productive lands are closely connected with flocks and herds.

But if our present methods shall continue, and our exportation of cereals increase, the time must come, unless our experience is to be wholly unlike that of other countries, when, to increase the production of our lands we must at last have recourse to the same methods which have long obtained in great Britain and upon the Continent, and in the New England, Middle, and Atlantic States of our own country, viz., the application to our soils of those mineral constituents which now are being so rapidly removed. When that time comes, as come it assuredly must without some modification of our methods, it will be found that the profitable production of the cereal crops at the prices we now obtain for them will be an impossibility. Indeed, already in many parts of the country the continued production of corn, as in the past, is found to be almost without profit, and there have sprung up many factories hoping by its manufacture into other products to increase the profits in its production.

The manufacture and sale of commercial fertilizers has rapidly developed during the past few years in our country, and already reaches an annual aggregate of many millions of dollars.

In Great Britain, there was imported in a single year 394,843 tons of fertilizing materials, worth $20,049,042. Every corner of the earth and island of the sea has been ransacked, almost, to supply her with the means for increasing her crops. Within five years from the time when Liebig called attention to the deposits of guano, her importation of this most valuable fertilizer reached the enormous amount of 283,300 tons in a single year, and her consumption of superphosphate is estimated annually at 250,000 tons.

But, in addition to this, her importations of cereals and breadstuffs for consumption within her borders has added greatly to the aggregate supply of her material for the enrichment of her farming lands. As a result of this enrichment of the soil, we have seen the productiveness of these farming lands of Great Britain, within the past thirty years, enormously increased, until it appears, according to the authority of one of their foremost agriculturists, they have reached about the last limit of profitable production in their agriculture.

In connection with this subject of commercial fertilizers, it is interesting to consider the results which have followed the chemical control which has been maintained over this great industry. All will under-

stand that the determination in a commercial fertilizer of the amount of those constituents of which our various crops are composed, is a chemical question, and we have, in most of the states, chemists appointed, whose duty it is to analyze and report upon such fertilizers as are offered for sale. The result of this chemical supervision gives abundant evidence that this work of the agricultural chemists of the country has, even in a pecuniary sense, very greatly added to the profits of the farmer.

The following table contains the results of analyses of commercial fertilizers, made by different chemists in different states during the past thirteen years, and shows the improvement which has taken place during these years, both in quality and price:

IMPROVEMENT IN FERTILIZERS.

Years.	No. analyzed.	Chemist.	Average market price.	Average value.	Per cent of value to cost.
1868	16	Johnson.	$59 47	$21 36	36
1870–2	15	Bruckner	50 07	17 60	35
1871–2	11	Storer.	56 36	36 32	64
1872	36	Collier	....	....	67
1873	10	Goessman	....	....	67
1881	36	Dabney.	37 40	33 26	89
1881	57	Genth.	34 79	32 93	95

From the above results, it will be seen that, within the past thirteen years, the average price per ton has fallen from $59.47 to $34.79, or 41.5 per cent, while the intrinsic value per ton has increased during the same period from an average value of $21.36 to $32.93 per ton, or 54.2 per cent. In other words, did the same relation of value to cost obtain to-day which existed in 1868, the average cost of the fertilizers analyzed by Dr. Genth would have been $91.68 per ton, whereas it is $34.79, equal to 38 per cent only, thus showing that the purchaser of commercial fertilizers of to-day makes an average saving of 62 per cent.

Not only has this great saving been effected during the past few years, but it is to be observed, also, that the basis of valuation of these fertilizers has also been changed, and in this way increased greatly the benefit accruing to the purchaser and consumer of these commercial products. For example, in 1869, the value generally given to soluble phosphoric acid was 16¼ cents per pound, while now the same constituent is estimated at 12 cents per pound.

The above statement but partially represents the whole truth in this matter—for, besides these, as one might say, legitimate products, there

were sold in these earlier days, less than ten years ago, as fertilizers, material not worth, in fact, the barrels in which the stuff was packed for market; as, for example, the "What is It," as it was called, which in reality was only the powdered gangue rock of an abandoned gold mine. In another case, harbor mud was put up and sold as a valuable fertilizer.

But, at the present time, owing to the careful supervision which this matter receives, it is somewhat rare to meet with such cases of fraud; although, within a year, my attention was directed to one of my own analyses of one of these almost worthless products, where the results of the analysis had been increased one hundred fold by carefully removing the decimal points, in my report of the analysis, two places to the right, so that the one-tenth of one per cent of potash present was made to appear as ten per cent, and so throughout the entire analysis.

Our country has not been alone in this experience, though we have passed through it much sooner than did England and Germany. In 1855, Professor Voelcker declared "that, if ever there was a time when the agriculturist had need to exercise special caution in the purchase of artificial manures, that time is the present, for the practice of adulterating standard fertilizers, such as guanos, superphosphates, and so forth, has reached an alarming extent." One of our foremost agriculturists has recently declared that, "I have come to the conclusion that there is no way in which the Department of Agriculture can aid the farmers of this country more than by a careful analysis of the commercial fertilizers sold on the market. The use of these fertilizers has become a necessity in all the older states—a necessity which is to increase from year to year. There is not one farmer able to tell their value except by actual trial, and that must be made after his money is gone."

In concluding this paper, we would say that, from the data presented, it appears to be established that, during the past twenty years, the productiveness of our soil has sensibly decreased; and in those sections where the fertility has been fully maintained, it has been largely due to the fact that our farmers have resorted to the same means which, in Great Britain and upon the continent, have abundantly proved sufficient to maintain, and greatly increase, the acreage yield of crops.

We have also called attention to another method by which further deterioration of our lands will not only cease, but they may again in time be restored to their original productiveness.

So long as a foreign demand for our agricultural products exists, and

increased prices shall be obtained, there is little doubt but that in the future, as in the past, exportation will continue, and the results are inevitable. So, too, the system of large farms and large crops in the aggregate, though with scanty acreage yield, is possible now with the comparatively scattered population of the great West. It is more than probable that, when our population shall have increased from 50 to 100 or 150 millions, we shall be forced to abandon methods of farming which already are regarded with apprehension by those who have investigated them.

But there remain other methods than those indicated for the improvement of our lands, the discussion of which will be reserved for another paper at some future time.

CHAPTER XV.

(*a.*) Method of analysis of sorghum and maize juices used by the author in his investigations.
(*b.*) Comparison of analyses with polarization of juices.
(*c.*) Specific gravity of juices.
(*d.*) Tables of average composition of sorghum juices at different specific gravities.
(*e.*) Tables of average composition of maize juices at different specific gravities.
(*f.*) Preparation of re-agents for analysis of sorghum and maize juices.

ANALYSIS OF SORGHUM AND MAIZE—METHOD.

Since the results which have been given in this volume are practically those secured by the author, during his investigation of this subject, as the chemist of the Department of Agriculture, at Washington, and as the conclusions are drawn from them, the accuracy of the results and methods can not be too clearly established. This will be sufficient explanation for the insertion of the following:

At the meeting of the National Academy of Sciences, held at Philadelphia, in November, 1881, a paper was presented by Dr. Peter Collier, on invitation, giving, in brief, some of the points brought out in the investigation conducted by him at the Agricultural Department at Washington, on the subject of sugar from the sorghum and maize. After the discussion, following the reading of this paper, a record of the meeting says:

Mr. Silliman offered the following resolution, and moved its reference to the council:

Resolved, That the subject of sorghum sugar, the experimental results on which obtained, during the three or four years last past, by Dr. Peter Collier, of the Agricultural Department, submitted in brief, by invitation, to the Academy, at Philadelphia, in November, 1881, is, in the opinion of the Academy. of sufficient importance to be referred to a committee of chemists, members of this Academy, with the request that they give Dr. Collier's results and methods a careful consideration, and report, at their earliest convenience, the conclusions to which they come.

The resolution of Mr. Silliman was agreed to.

This resolution was favorably reported from the council, and the following committee has been appointed by the president:

Messrs. Brewer, Chandler, Johnson, Silliman, and J. L. Smith, from the Academy. Experts, not members of the Academy: Dr. C. A. Goessman, Massachusetts Agricultural College, Amherst; and Dr. Gideon E. Moore. 69 Liberty street, New York.

It may be well to state, for the information of those interested in this matter, that the National Academy of Sciences, incorporated by Congress in 1863, is, by the fundamental law of its organization, constituted the adviser of the government in all matters of science referred to it for investigation by any department of the public service, and has often acted in this capacity.

The following is taken from the unanimous report of this committee upon the results of the above investigation:

The Analytical Methods Employed.

The committee, after a careful examination of the analytical methods employed by the chemical division of the Department of Agriculture, find that they are entirely sufficient for the work to be done. The details of the processes for the volumetric determination of sucrose and grape sugar are fully exhibited. These methods have been skillfully adapted to the character of the proximate constituents of the complex juices to be analyzed, and are among the best known to science.*

These methods have been employed with precautions adapted to the exigencies of the special problems for the solution of which the investigation has been instituted. By a judicious system of checks and control, and by the reduction to the lowest limits of the personal error of the observer, the accuracy and constancy of the results have been assured as far as, in the present state of our knowledge, such end can well be attained.

The care with which the methods for the determination of cane sugar have been tested, and the probable error determined, enlists our confidence. The reserve with which the chemist has refrained from accepting the results as conclusive, until, by repetition and variation in the methods, he had exhausted the means at his command to prove them to be erroneous, is in the true spirit of scientific research.

The analytical work prior to 1882 comprises the enormous number of nearly 4,500 analyses of forty varieties of sorghum and twelve varieties of maize, covering all the later stages of development of the growing plant. Such an amount of analytical work as is implied in the careful conduct of nearly five thousand quantitative analyses by the most rigid system and subdivision of labor in the work—a system in

* The limits of error, as shown to the committee from a considerable number of unpublished determinations, sustain the conclusion that the method employed for the estimation of cane and grape sugars was exceptionally accurate, and more subject to a minus error of 0.2 per cent on a 10 per cent solution of pure sugar, than to a plus error.

which each assistant was, for the time, devoted exclusively to one thing, *e. g.*, determinations of density by the balance, volumetric determinations of glucose and sucrose, polarizations, ash determinations, total solids, ash analyses, analyses of the seed, quantitative determinations of acids and other proximate constituents of the juicies at seventeen different stages of growth of the plant and after maturity. By this system each co-worker became thoroughly expert as a specialist in his own duty; and it was thus possible, by this system, to test the accuracy of the work by submitting identical samples in duplicate and separate numbers for analysis by the same and by different co-workers—a crucial test of verification.

The committee have critically examined the work done in this way, and the details show a suprising agreement.

Method of Analysis.

It is obviously of the first importance that the results of analyses given should have been obtained by reliable methods.

Every precaution has been taken to guard against error and to control the results.

In the first place, it may be remembered that each assistant, in the routine work assigned him, was necessarily free from all prejudice as to what result he was to expect, for each sample of juice, syrup, or cane examined was known only by a number, and this was known only to one who himself performed no analytical work.

Every questionable result was at once repeated, and many duplicate samples of juice, under different numbers, and without the knowledge of any of those engaged in the analyses, were from time to time analyzed.

Each new lot of either of the re-agents employed in analysis was carefully tested, and indeed nothing was omitted which would tend to accuracy in work.

Those familiar with chemical methods, and considering the vast amount of work actually performed in these analyses, are aware that absolute accuracy is not to be expected; but whatever errors there may be are certainly within very narrow limits, and the general results furnished in the foregoing analyses may be confidently relied upon as being practically near approximations to the truth.

The Analytical Processes for the Examination of the Canes.

One or more stalks of the variety of sorghum to be examined were selected in the experimental field, and, after recording the stage of development and general appearance of the canes, a number was affixed

by which they could be distinguished during the remainder of the examination. After being cut and brought to the laboratory, the length of the stalk from butt to the extremity of the head, its entire weight, and diameter at the butt, were taken. It was then stripped and topped, as in the usual way of preparation for the mill, and again weighed. The "stripped stalk" was then expressed in a three-roll mill, and the juice collected in a weighed flask and weighed to determine "per cent of juice" in the stripped stalk. The specific gravity was determined with a piknometer, after an interval of an hour to allow the escape of air bubbles and the subsidence of suspended starch. For the determination of the "total solids" in the juice $2^{cm3.}$ were accurately measured into a weighed porcelain dish 6 to $7^{cm.}$ wide and 1. 5 to $2^{cm.}$ deep, the bottom of which was previously covered with coarse sand to a depth of $.75^{cm.}$ to insure complete desiccation. After twelve to fourteen hours' drying at 85° to 90° C., there was no further loss of water. The weight of the residue in grams, divided by twice the specific gravity, gave the per cent of "total solids."

For the determination of glucose and sucrose, $100^{cm3.}$ of the juice were taken and defecated by the addition of $25^{cm3.}$ of solution of basic acetate of lead in water. The filtrate from the lead precipitate, which was perfectly clear, was, in many instances, polarized, and then devoted to the methods of volumetric analysis. Owing to the degree of dilution, every $10^{cm3.}$ of filtrate represented $8^{cm3.}$ of juice.

For the determination of glucose $10^{cm3.}$ of the filtrate were taken; for sucrose, $5^{cm3.}$. The portion for glucose was diluted with about 50 to $75^{cm3.}$ of water, and about the same amount of Fehling's solution added. The porcelain dish containing the whole was placed upon a water bath kept at such a temperature by steam, that the liquid in the dish rose to about 75° C., but no higher. After an interval of thirty minutes, the dish was removed and allowed to cool. The portion for sucrose was diluted with $100^{cm3.}$ of water, $5^{cm3.}$ of hydrochloric acid (sp. gr. 1.05) added, and the mixture heated in a porcelain dish on a steam bath for a half hour, the temperature not rising above 90° C. The inversion being complete, an excess of Fehling's solution was added, depending in amount on the maturity of the cane, and the liquid allowed to remain thirty minutes longer on the bath, after which it was removed. When the suboxide of copper had completely settled, in the case of both sucrose and glucose, the supernatant liquid was decanted into a beaker placed in front of each dish, and hot water was poured over the suboxide. This process was repeated, pouring the first liquid decanted into a second beaker, and so on until it could be poured away free from any oxide, and the original dish was nearly free from alkali.

All the wash waters were then passed in order through a filter, taking care to bring as little as possible of the suboxide upon the filter.

The suboxide on the filter and in the beakers was dissolved in an acid solution of ferric sulphate, free from nitric acid and ferrous salt, or more conveniently in an acid solution of ammonia ferric alum (which is more easily obtained free from impurities), and poured upon the suboxide in the original dish. All the copper suboxide being dissolved, it is brought into a liter flask, diluted with water to *about* $500^{cm3.}$, and acidified strongly with sulphuric acid. It is then ready to be titrated in the usual manner for the amount of reduced iron, the number of $^{cm3.}$ of permanganate used giving easily the weight of glucose represented by the suboxide of copper, as shown in report for 1879, p. 66.

This method for determining glucose depends upon the following facts:

1. That two molecules (360 parts by weight) of glucose ($C_6H_{12}O_6$) will reduce from Fehling's solution five molecules of cuprous oxide ($5\ Cu_2O$).

2. That the five molecules of cuprous oxide thus precipitated will reduce in acid sol. five molecules of ferric sulphate ($Fe_2(SO_4)_3$) to form ten molecules (1,520 parts by weight) of ferrous sulphate ($FeSO_4$), as is explained by the following equation:

$$\left\{\begin{matrix} 5\ Cu_2\ O \\ 715\ \text{parts} \end{matrix}\right\} + \left\{\begin{matrix} 5\ Fe_2\ (S\ O_4)_3 \\ 2{,}000\ \text{parts} \end{matrix}\right\} + \left\{\begin{matrix} 5\ H_2S\ O_4 \\ 490\ \text{parts} \end{matrix}\right\} = \left\{\begin{matrix} 10\ Cu\ S\ O_4 \\ 1{,}595\ \text{parts} \end{matrix}\right\} + \left\{\begin{matrix} 10\ Fe\ S\ O_4 \\ 1{,}520\ \text{parts} \end{matrix}\right\} + \left\{\begin{matrix} 5\ H_2\ O \\ 90\ \text{parts} \end{matrix}\right\}$$

The ten molecules of ferrous sulphate thus formed, will decolorize one molecule (316.2 parts by weight) of potassium permanganate ($K_2\ Mn_2\ O_8$), thus:

$$\left\{\begin{matrix} 10\ Fe\ S\ O_4 \\ 1{,}520\ \text{parts} \end{matrix}\right\} + \left\{\begin{matrix} K_2\ Mn_2\ O_8 \\ 316\ 2\ \text{parts} \end{matrix}\right\} + \left\{\begin{matrix} 8\ H_2\ S\ O_4 \\ 784\ \text{parts} \end{matrix}\right\} + \left\{\begin{matrix} 5\ Fe_2\ (S\ O_4)_3 \\ 2{,}000\ \text{parts} \end{matrix}\right\} + \left\{\begin{matrix} 2\ Mn\ S\ O_4 \\ 302\ \text{parts} \end{matrix}\right\} + \left\{\begin{matrix} K_2\ S\ O_4 \\ 174.2\ \text{parts} \end{matrix}\right\} + \left\{\begin{matrix} 8\ H_2\ O \\ 144\ \text{parts} \end{matrix}\right\}$$

By following this explanation, it appears that two molecules of glucose are exactly represented by one molecule of potassium permanganate, as will appear from the following, by omitting the second and third members of the series. Thus:

$$\left\{\begin{matrix} 2\ C_6\ H_{12}\ O_6 \\ 360\ \text{parts} \end{matrix}\right\} = \left\{\begin{matrix} 5\ Cu_2\ O \\ 715\ \text{parts} \end{matrix}\right\} = \left\{\begin{matrix} 10\ Fe\ S\ O_4 \\ 1{,}520\ \text{parts} \end{matrix}\right\} = \left\{\begin{matrix} K_2\ Mn_2\ O_8 \\ 316.2\ \text{parts} \end{matrix}\right\}$$

In other words, 316.2 parts by weight of potassium permanganate are equivalent to 360 parts of glucose, or one part of permanganate corresponds to 1.1385 parts of glucose. If, then, the amount of permanganate decolorized be multiplied by 1.1385, it will correctly represent the amount of glucose present. So much for the theoretical explanation. In practice, it is found that each chemist must determine for himself his titration error by estimations made upon sugar of known purity.

This individual error is due to the difficulty in determining the exact end re-

action; experience has shown, in the course of this work, that the point where the color of the permanganate barely appears in the rapidly agitated liquid, is nearly identical with the true end reaction. Some operators carry the titration a little further, until a faint rose tint is permanent for about two seconds. Each man who has done this work, has carefully determined his titration error, and all figures submitted have been corrected therefor. The iron solution works best if very strongly acidulated with sulphuric acid. The most convenient strength for the permanganate solution, is 4.392 grams to the liter, equal to .005 grams glucose for each cubic centimeter.

In order to determine what errors there may have been in estimating glucose and sucrose by this method, the following experiments were carried out. Every portion of Fehling solution used, was heated by itself in the steam bath for an hour, to determine if it remained unreduced in absence of sugar. In all cases it was quite unchanged. Several solutions of dry granulated sugar, containing about .10 per cent of impurities, were made of such a strength that every $5^{cm^3.}$ contained .5000 grams of pure sucrose, or, on inversion, .5263 of inverted sugar.

Of solution No. 1, four portions were measured out of $5^{cm^3.}$ each, and submitted to the usual course of analyses, with the following result:

Experiment.	Titration.	Glucose found.	Glucose used.	Per cent found.
No. 1	104 2	.5210	.5263	98.99
No. 2	103.4	.5170	.5263	98 24
No. 3	104 4	.5220	.5263	99 18
No. 4	104.5	.5225	.5263	99 28
Average	.....	.....	..	98.93

The specific gravity was found by the piknometer to be 1.034. The solution contained, therefore, 9.67 per cent of sugar. By titration we find 9.57 per cent of sugar, and polarization of the solution gave 9.63 per cent of sucrose.

Of the solution No. 2, nine portions were taken of $5^{cm^3.}$ each, to six of which (Nos. 1–6) $5^{cm^3.}$ of the usual dilute acid were added, and to the remaining three, $10^{cm^3.}$; otherwise the usual course of analysis was pursued. The entire lot was carried through simultaneously on the same steam bath. The results were as follows:

Experiment.	C^{m3}· of permanganate.	Glucose found.	Per cent of original.	Per cent sucrose in solution.
No. 1	104 5	.5225	99.28	9 60
No. 2	105 3	5265	100 10	9 67
No. 3	106 6	.5330	101.26	9 79
No. 4	108 3	5415	102.88	9 95
No. 5	107 4	.5370	102 02	9 86
No. 6	108 1	.5405	102 70	9.93
No. 7	104 6	.5230	99 38	9 61
No. 8	104 4	5220	99 18	9 59
No. 9	105 2	.5260	99 94	9.66
Average	......	..	100.74	9.74

The specific gravity was found to be 1.034, and the per cent of sugar in the solution was therefore: By calculation, 9.67; by titration, 9.74. An estimation of total solids, gave 9.70 per cent. The addition of the larger amount of acid, apparently, had the effect of lowering the per cent of sucrose found. In no case was the error in the final result sufficiently large to be of account in work on such a large scale.

Fifteen portions of 5^{cm3}· each were taken from solution No. 3. Its specific gravity was 1.035, and the per cent of sucrose 9.66.

Submitted to analysis in the usual way, the results were:

Experiment.	C^{m3}· of permanganate at .005 glucose.	Glucose found.	Sucrose found.	Per cent of sucrose.
No. 1	107 0	.5350	.5082	9.82
No. 2	108 0	5400	.5130	9 91
No. 3	106.0	5300	.5035	9 73
No. 4	106 0	.5300	.5035	9 73
No. 5	107 0	.5350	.5082	9 82
No. 6	106 0	.5300	.5035	9 73
No. 7	108 7	.5435	.5163	9 98
No. 8	106 8	5340	.5073	9 80
No. 9	106 3	5315	5049	9 76
No. 10	106.5	5325	.5059	9.78
No. 11	106 8	.5340	.5073	9 80
No. 12	106 3	.5315	5049	9 76
No. 13	106 0	5300	5035	9 73
No. 14	104 9	.5245	.4983	9 63
No. 15	105 3	5265	.5002	9 66
Average	......	......	......	9.77

By calculation	9.66
By titration	9.77

The results of thirty determinations may be stated as follows:

	Per cent.
Sugar solution containing	9 67
No. 1. Four determinations, by titration (average)	9.57
No. 2. Nine determinations, by titration (average)	9.74
No. 3. Fifteen determinations, by titration (average)	9.77
No. 1. One polarization	9.63
No. 2. One determination of total solids	9.70
The lowest result was	9.50
The highest result was	9.98

It may be assumed, therefore, that *the greatest error is not more than minus one-tenth or plus three-tenths of one per cent*, which, in the work under hand, can not be considered excessive.

In order to have a check on the process, when applied to juices as well as pure sugar solutions, polarizations were made in a large number of cases. The following table gives a series of average results for several years.

COMPARISON OF ANALYSIS WITH POLARIZATION OF SORGHUM JUICES.

In the examination of sorghum juices in 1882, there was taken, for the purpose of controlling analytical results, the polarization of the juices. In all, 855 juices from the several varieties of sorghum under cultivation, and in every condition of development, were thus examined, and the average results are as follow:

	Per cent.
Sucrose by analysis	10 938
Sucrose by polarization	10.969
Or as 100 : 100,265.	

The first 548 analyses made gave even closer results, viz.:

	Per cent.
Sucrose by analysis	10.585
Sucrose by polarization	10.577
Or as 100.074 : 100.	

The above results prove that the analytical method employed in these investigations is as accurate as could be desired, and that the results secured by this method are entitled to entire confidence in their substantial accuracy.

In 1881, the average results of 697 analyses of sorghum and 103 of maize juices gave:

	Per cent.
Sucrose by analysis	10.598
Sucrose by polarization	10.161
Or as 100 : 95.9.	

The following table shows the results of analyses and polarizations of the juice, arranged according to the per cent of sucrose in the juices, from 1 to 19 per cent in the sorghums, and from 1 to 14 per cent in the maize juices. It will be seen that the agreement is as close between analysis of juices poor in sugar and comparatively richest in glucose, as between the best juices. This is very important, as

indicating the absence of any optically active constituent in the normal juice, other than sucrose.

SUMMARY OF ANALYSES AND POLARIZATION OF SORGHUM AND MAIZE JUICES.

Sorghum.				Corn.		
Number of analyses.	Sucrose.	Sucrose by analysis.	Sucrose by polarization.	Number of analyses	Sucrose by analysis.	Sucrose by polarization.
	Per cent.					
4	1 to 2	7.00	5.17	2	3.24	2.74
4	2 to 3	11.09	10.19	2	4.78	4.42
19	3 to 4	62.03	56.14	7	25.33	22.07
18	4 to 5	82.29	72.33	13	59.16	56.20
40	5 to 6	222.79	220.55	21	114.53	110.83
52	6 to 7	337.34	332.25	7	45.41	43.53
41	7 to 8	311.86	297.21	17	127.51	120.59
37	8 to 9	310.02	291.40	6	49.73	54.75
40	9 to 10	377.92	353.74	4	38.72	34.18
43	10 to 11	451.66	443.50	15	159.27	159.47
59	11 to 12	680.81	652.07	6	68.85	65.10
80	12 to 13	1009.14	946.99	1	12.55	11.74
94	13 to 14	1272.63	1257.19	2	26.40	21.68
62	14 to 15	890.76	868.98			
48	15 to 16	746.51	699.47			
25	16 to 17	412.34	397.04			
25	17 to 18	436.26	409.94			
6	18 to 19	110.53	107.00			
697		7,732.98	7,421.16	103	745.48	707.30
Ratio		100	95.96		100	94.87

MAIZE JUICES IN 1880.

Number of analyses	17
Average sucrose by polarization	7.48 per cent.
Average sucrose by analysis	7.41 per cent.

SORGHUM JUICES IN 1880.

Number of analyses	40
Average sucrose by polarization	12.68 per cent.
Average sucrose by analysis	12.88 per cent.

In 1879, this comparison was, between sorghum and sugar-cane, as follows:

	Number of analyses.	Average sucrose by volumetric analysis.	Average sucrose by polariscope.
		Per cent.	*Per cent.*
Sorghum	22	13.26	13.15
Sugar-cane	6	13.30	13.09

In 1881, the number of these comparisons was very greatly increased, being between 697 analyses of sorghum and 103 analyses of maize.

Calling the value of the sucrose, as found by analysis, 100, the value indicated by the polariscope was 94.87 for the maize, and 95.96 for the sorghum. The nearly constant difference of about 4 per cent less sucrose, as determined by these polariscope tests, than was found by cuprous precipitation, was, for the time, attributed to a portion of invert sugar, and to various causes, which probably were misconceptions, seeing that this discrepancy disappears almost entirely in the results of 1882, viz.: Number of analyses and polarizations 517, of some forty varieties of sorghum.

Total polarization, 5,440.76; average percentage, 10.524.

Total by analysis, 5,433.72; average percentage, 10,510.

$$10.510 : 10.524 = 100 : 100.13.$$

Each result of the 517 is of record, but the general result given suffices. The conclusion seems justified, that any differences existing in the polarization and analyses with *normal* fresh juices, are only differences incidental to the work, and are not caused by any active rotatory substance present other than *sucrose.* If the juice is *abnormal,* very wide differences may exist. This was conspicuous in the mill work at the department in 1881, both in juices and syrups.

The comparisons in 1879–1881, between large numbers of determinations, by the cuprous precipitation and by polariscope, appeared to sustain the opinion that there was a pretty constant difference in favor of the volumetric method, *i. e.*, that the polariscope, for some unknown reason, failed to detect as much sugar as was demonstrated by the method of precipitation. These differences are set forth below, together with the very satisfactory results of over five hundred similar determinations made in 1882, from which it clearly appears that the discrepancy formerly noticed is apparent and not real. This conclusion removes any doubt which hung over the practical value of the optical method; and this is practically of much moment, for in the rapid operations of the sugar plantation, during the pressure of the crop, the polariscope is nearly the sole dependence of the superintendent in judging, many times daily, how his juices are running.

The conclusions which may be drawn from our experiments are, that, in experienced hands, the relative results are to be entirely relied upon; and, when the conditions which have been detailed are followed, the absolute results are also satisfactory.

Duplicate Analyses of Sorghum Juices.

For the purpose of controlling the results of analyses, there were made, during the seasons of 1881–1882, very many analyses of sorghum juices in duplicate.

In no case did those who were engaged in the analyses have any reason to suspect that they were at work upon duplicates, the samples having been prepared and sent into the laboratory under their several numbers, as being individual specimens of juice. Thus, Nos. 105 and 113 were duplicate juices, and so on; Nos. 107 and 115 being also duplicates.

It will be observed that the agreement is quite as close as could be expected in work of such a character, and that the average results given at the close of this table show that in the analytical work there is nothing to cause doubt as to the substantial accuracy of the work recorded.

DUPLICATE ANALYSES OF SORGHUM JUICES, 1882.

Number of analysis.	Specific gravity.	Glucose.	Sucrose.	Solids.	Polar.	Number of analysis.	Specific gravity.	Glucose.	Sucrose.	Solids.	Polar.
105	1 042	5.40	2 72	1 69	3 06	113	1 042	5 65	3 13	.87	3 20
107	1 034	3 25	3 73	1 30	4 24	115	1 034	3 26	3 83	1 25	3 72
109	1 038	3 27	4.69	1 29	5.28	114	1 038	3 27	4 86	1 21	5 24
111	1 053	3.38	8 30	1 14	8 01	116	1.053	3 41	7 82	1.57	7 90
133	1 072	2 10	12 96	3 07	13 44	136	1 073	1 93	12 81	3 27	13 53
158	1 068	1.15	11.79	3 26	12 06	160	1 069	1 16	11 59	3 03	12.14
150	1 063	2 79	10 06	2 55	10 21	157	1 063	2 92	10 23	2 21	10 28
161	1.072	.93	13 31	3 28	13 60	163	1 073	93	13 31	3 54	13 60
168	1 057	3 23	8 37	2·35	8 68	180	1.057	3.18	8 26	2.29	8 69
169	1 056	2 02	8 92	2 63	9 36	181	1 056	2 05	8 78	2 45	9.34
173	1 068	1 57	12 03	2 64	12 44	179	1 068	1.53	11 96	2.70	12 55
182	1 057	1 48	8.48	3 41	8 54	183	1.057	1 49	8 45	3 09	8 52
189	1 058	2 13	10 41	2.50	......	202	1 059	2 18	9 99	..	10 48
191	1 057	3 29	8.50	2 24	....	203	1.056	3 29	7 91	2 75	8 47
192	1.069	2.44	11 65	2 79	.	204	1 069	2 41	11.60	2.88	12 05
194	1 056	2 42	8 86	2 24	9.01	205	1.056	2 46	8 70	2 55	....
206	1.038	.67	5 72	2 92	.	207	1.038	67	5.93	2 88	.....
224	1 071	1 05	13 15	3 27	13 44	226	1 071	1 12	13 37	3 26	13.48
214	1 069	1 89	12 48	2 73	12 91	227	1.069	1.87	12 73	2 58	12 02
216	1.073	1 82	12 94	3 20	13 68	228	1 073	1 54	13 50	2.76	13 76
212	1.071	84	13 39	2 98	13 53	229	1 071	.89	13 73	2 98	13.48
220	1 071	1 19	12 54	3 40	13 23	230	1 071	.93	11.11	5 15	13.48
221	1 061	4 11	8 22	2 81	8 70	231	1 061	4 04	8 49	2 54	8 64
219	1.061	1.64	10.31	3 24	10 93	232	1 062	1 68	10 95	2.56	11 02
	1.435	54 06	233 53	60 43	195 34		1 439	53 86	233.04	60 37	194 59
Average	1 0598	2 252	9.729	2 627	10.281	Average	1 0600	2 244	9 710	2 625	10 242

LIST OF DUPLICATE TESTS MADE IN SORGHUM ANALYSES, 1881.

Number of analysis.	Per cent of sucrose by titration.	Per cent of sucrose by polariscope.	Per cent of glucose by titration.	Specific gravity of juice.	Per cent of solids not sugar.
351	7.33	7.02	2.68	1.045	2.47
359	7.12	7.25	2.75	1.047	2.54
371	3.76?	......	2.61	1.035	2.04
373	10.67	......	2.61	1.030	2.46
385	16.35	15.48	0.12	1.046	—1.42
	16.20	......	......	......	......
412	11.43	11.95	2.05	1.064	2.26
437	11.75	11.06	2.17	1.063	1.84
413	9.55	9.00	3.95	1.061	1.91
436	9.27	8.94	4.21	1.060	2.00
415	5.49	4.95	2.73	1.041	2.06
434	5.34	5.00	2.91	1.040	2.08
416	7.21	6.58	2.72	1.049	2.22
439	7.05	6.59	2.84	1.047	0.71
417	7.59	7.25	2.03	1.047	2.36
432	7.28	7.25	2.34	1.047	2.32
424	5.34	......	6.17	1.054	2.77
438	5.88	5.36	6.22	1.054	1.75
426	5.62	......	3.19	1.044	2.49
431	5.21	5.06	3.49	1.043	2.42
427	4.14	3.80	5.44	1.044	2.24
440	3.98	3.74	5.77	1.044	2.08
429	4.11	2.72	5.16	1.039	1.46
435	3.29	2.80	5.47	1.039	1.49
430	2.03	1.29	5.93	1.036	1.59
433	1.72	1.27	6.03	1.036	1.95
441	9.02	9.18	3.02	1.058	2.75
452	9.49	9.21	2.82	1.057	2.87
443	4.00	7.25	2.38	1.047	5.98
445	7.32	7.21	2.42	1.047	2.67
446	6.68	6.09	2.61	1.046	2.75
455	6.16	6.18	2.69	1.046	3.01
447	3.84	......	5.95	1.045	2.41
451	4.04	......	5.86	1.045	1.34
449	3.13	2.76	5.36	1.040	2.71
457	3.15	2.85	5.44	1.040	2.79
466	7.02	6.95	2.62	1.048	4.76
468	7.01	......	2.55	1.049	6.79
467	5.72	......	1.59	1.041	4.45
461	5.49	5.31	1.50	1.041	4.96
470	3.03	2.87	3.51	1.034	3.80
463	3.01	2.93	3.39	1.034	4.03
476	5.64	4.32	2.34	1.043	4.29
462	5.94	4.40	2.25	1.043	4.27
472	14.53	14.15	.03	1.044	—0.20
	14.16	......	......	......	......
486	5.34	......	3.56	1.045	3.10
491	5.17	......	3.65	1.043	2.92
490	5.92	5.71	2.18	1.039	2.23
489	5.64	......	2.11	1.039	3.07
493	4.58	4.15	2.53	1.037	2.72
485	4.92	4.25	2.53	1.038	2.90
496	8.51	......	3.66	1.041	3.33
487	4.29	3.75	3.66	1.040	2.62
500	6.27	5.27	3.24	1.045	2.21
488	5.81	5.36	3.16	1.046	3.12
583	9.45	9.09	1.42	1.055	4.53
586	9.47	8.84	1.39	1.055	4.92
584	4.68	4.23	2.64	1.039	3.55
587	4.36	4.24	2.70	1.040	3.51
590	7.58	7.02	2.68	1.049	1.65
596	8.03	6.98	2.86	1.049	1.16
591	7.66	7.02	2.77	1.050	1.76
613	11.41	12.21	4.03	1.069	1.63
620	12.06	11.22	4.15	1.069	0.95
619	12.70	10.67	2.73	1.064	0.63
609	12.25	10.65	2.70	1.064	1.55
631	4.43	4.01	5.14	1.044	2.49
634	4.19	3.72	5.21	1.043	2.58
637	3.84	3.02	6.24	1.045	2.31
633	3.88	3.11	6.25	1.044	1.74
665	6.99	7.60	2.20	1.049	3.05
662	7.32	7.30	2.32	1.049	—1.53

LIST OF DUPLICATE TESTS MADE IN SORGHUM ANALYSES, 1881.—*Continued.*

Number of analysis.	Per cent of sucrose by titration.	Per cent of sucrose by polariscope.	Per cent of glucose by titration.	Specific gravity of juice.	Per cent of solids not sugar.
670	10.23	9.60	3 83	1 054	—0.78
673	9.55	8 93	2.17	1.054	2.74
678	15.05	14.67	1.04	1.079	2.72
680	15 15	14 82	1.10	1.079	2.48
683	12 44	12.14	1 98	1.069	2.55
679	12 22	12 12	1.98	1 069	2.54
765	12 79	12.19	2.06	1.071	2.42
773	12 46	......	2 03	1 071	2.78
771	12 07	10.33	1.39	1 064	1 58
766	10 93	10 27	1.30	1 064	2 90
791	10 15	8.88	4.29	1 062	1.60
788	9 64	8.88	4 47	1 062	1.99
795	12.15	9.73	3.63	1.065	0.51
786	10.55	9.72	3 67	1.065	2 21
804	5.29	8.09	2 28	1.940	2.33
811	5.16	4.73	2 42	1.040	2.51
803	8.42	....	4.42	1.055	2.04
810	8 26	7.90	4 52	1.058	2.15
818	9.20	8.56	1.50	1.050	1.81
824	13.60	8.69	1 46	1.049	—2.48?
826	11.45	......	1 39	1 078	6 03
828	13.43	......	1.21	1.077	4.31
834	15 73	15.14	1.69	1.082	2 54
836	15.87	15 31	1 69	1.082	2.64
833	15 62	15.53	1.69	1.082	2.65
842	16 07	......	1 78	1.083	2.69
831	23 66	23.15	.19	1.074	—0 39
	23 15	......	......	......	......
847	11.62	11.51	2.36	1.062	1 98
857	11.74	11 63	2 36	1.062	1.90
849	11 56	10 77	1.32	1.060	2.54
861	11.48	10.76	1 53	1.061	2.07
851	13.83	13.15	1 21	1.077	3.14
856	14.28	......	1.21	1 078	2.76
879	6 10	6.37	3.49	1.049	4.18
890	6.48	6 49	3.49	1 049	3 70
883	7.44	6.63	2.32	1 044	2.55
891	7.28	6.66	2.39	1.043	2.41
896	14 12	13.60	2.02	1.078	1.94
905	14.03	......	1.96	1 080	3.87
901	15 29	14.21	1 56	1.076	3.42
906	15 07	14.19	1.56	1.076	2.60
948	16.06	......	1.87	1.078	2.61
952	15.40	15.07	1 89	1.078	2.21
939	5.20	5.26	1.55	1.042	3.99
953	5.42	......	1 61	1.042	3 62
964	16 90	......	1.54	1 087	3.21
971	16 96	......	1 67	1.085	3.02
965	12 57	......	1.76	1.061	1 03
972	11.17	10.49	2 46	1.061	1.63
976	13.98	15 26	3.22	1 075	2 89
1001	13.66	12.97	......	1 074	1.90
974	15.80	14.69	1 21	1 078	3.01
1002	15.96	......	1 47	1 077	2.30
1012	15.67	......	1.70	1 085	6.73
1017	16.53	......	1.27	1.083	6 76
1016	9 65	8 86	5.57	1 065	5.06
1018	9.42	9.02	5.45	1 066	5.76
1019	18.05	17.10	1.21	1 089	3.28
1047	17.20	......	1.55	1 088	3 67
1030	13.86	......	3.00	1 080	3.14
1048	14.40	......	3.00	1 080	3.06
1065	16.00	15.33	1.73	1 083	2.40
1067	15 64	15.14	1.78	1 083	2 89
1050	11.77	7.41	5 19	1.059	1.92
1068	8 97	7.34	5 19	1 059	1.04
1091	9.54	9.03	4 93	1 065	3.41
1101	9 79	8.23	5 28	1.065	2.11
1090	14.27	12 92	1 51	1.073	2 51
1102	14.60	13.78	1.51	1.073	3.46

There was also made a series of analyses of solutions of known quantities of commercial cane sugar and of anhydrous glucose, both separate and mixed.

The results of these analyses are given in the following table. They show clearly the substantial accuracy of the analytical methods employed in the work which has been recorded; but it is interesting to observe that, while the specific gravity, polarization, and analytical results for each constituent agree very closely in the duplicate analyses made, there is found, as the aggregate of four of the analyses where sucrose alone was taken, as follows:

	Grams.
Sucrose taken	17.63
Sucrose found	17.58

Also, in those four cases where there was taken anhydrous glucose, the following results were obtained in the aggregate:

	Grams.
Glucose taken	17.12
Glucose found	17.11

But in these cases, eight in all, in which both sucrose and glucose were present in the solutions analyzed, the aggregate results were as follows:

	Taken.	Found.
	Grams.	*Grams.*
Sucrose	20 505	22 68
Glucose	19 810	20.39

It will be seen that, while the amount of glucose taken is approximately equal to that found, as in the case of analyzing the solution of glucose alone, still the amount of sucrose found is 10.4 per cent greater than the amount taken. This result is, in all probability, due to the fact, that there existed as impurity, in the anhydrous glucose taken, a certain quantity of some product intermediate between starch and glucose, which, while not reducing the Fehling solution in the estimation of the glucose, was converted into glucose by treatment with acid in the estimation of the sucrose:

TESTS OF ACCURACY.

Number of analysis.	Sucrose taken.	Glucose taken.	Sucrose calculated.	Glucose calculated.	Sucrose found.	Glucose found.	Total solids found.	Polarization.	Specific gravity.
87	5 00	.00	4 9050	000	5.05	.00	4.94	4.89	1.015
88	2 50	2 50	2.4025	2 405	2.43	2 49	5.25	4.25	1.015
89	.00	5 00	.0000	4.820	.07	4 78	5.02	3 49	1 0143
199	5.00	.00	4 9050	.000	4.72	00	5 38	4.92	1.016
200	2.50	2 50	2.4525	2 405	2 26	2.38	4.96	4 04	1 016
201	.00	5.00	.0000	4.820	.11	4.84	4 96	3.51	1 0154
1131	2.00	2 00	1 9550	1 875	2 31	1.91	3 88	3 13	1 013
1138	2 00	2 00	1 9550	1.875	2 12	1 96	3.82	3.04	1.013
1134	4 00	2 00	3.9100	1.875	3 95	1 90	5.82	4 92	1 020
1136	4 00	2.00	3.9100	1 875	3.68	1.99	5.75	5.00	1 020
1132	2 00	4 00	1.9550	3.750	2 14	3.77	5 63	4 65	1 020
1139	2.00	4 00	1.9550	3 750	2 48	3 79	5 65	4 51	1 020
1135	.00	4 00	.0000	3.750	.49	3 78	3.83	2 54	1 013
1137	.00	4 00	.0000	3.750	.64	3.71	3 81	2 58	1 013
1133	4 00	.00	3.9100	.000	3 82	.10	3.86	3 90	1 013
1140	4 00	.00	3.9100	.000	3.99	.10	3 93	3.92	1.013
	39.00	39 00	38.1750	36 930	40.26	37.50	76.49	63.29	......

Tests of the Accuracy of the Chemical Work.

In this investigation of the author, at the Department of Agriculture, there was taken every reasonable precaution to secure accurate results in the analytical work.

The several methods of checks and control have been such, that, although errors may exist in individual analyses, it is impossible that the general results recorded should be other than a very close approximation to the truth.

It will be seen in another place, that the average results in 1882 of the analyses of 855 sorghum juices gave 10.998 per cent of sucrose by precipitation, while the same juices gave an average of 10.966 per cent by the polariscope; or, as 100 : 100.255, practically identical results.

During the season of 1882 there were made, in all, analyses of 24 juices in duplicate; and, as has been said, none of those engaged upon these analyses had any knowledge of the fact that duplicate juices were present in the twenty or more samples under analysis daily.

The average results of these 24 analyses, in duplicate, are as follows:

Specific gravity	1.0598	1.0600
Per cent sucrose	9.726	9 710
Per cent glucose	2 252	2.244
Per cent solids not sugar	2 627	2.625
Per cent polarization	10.281	10 244

These results are practically identical.

In like manner, during 1881, there were made 72 analyses in duplicate; and, as will be seen by consulting the tables giving the results, the agreement was as close as could be expected with work of this character.

SPECIFIC GRAVITY.

By specific gravity is meant the relative weight of any substance, solid, liquid, or gaseous, as compared with water (which is taken as the standard for solids and liquids), or as compared with air (which is taken as the standard for gases).

In the case of liquids, the determination of the specific gravity is easy, and may be found by first filling a bottle (the weight of which is known) with pure water, as rain-water, then finding the amount of water, by weight, which the bottle will hold. By then filling the same bottle with the liquid, the specific gravity of which it is desired to know (as, sorghum juice), and weighing it, we may learn the weight of a certain volume of the liquid, and also the weight of an equal volume of pure water. If, now, we divide the weight of the sorghum juice by the weight of the water, we ascertain the specific gravity of the juice.

For convenience, it is customary to use bottles which hold a certain definite weight of pure water, as 100 or 1,000 grams, and then it is only necessary to weigh the bottle full of juice, and the specific gravity is at once shown by the weight.

Such bottles are known as piknometers; but they are unnecessary. The only precaution to be taken in the determination of the specific gravity of sorghum juices is, that they should be allowed to stand a sufficient length of time (from one-half an hour to an hour) after they have been expressed by the mill, to allow the small bubbles of air present to escape, since these would, of course, diminish the specific gravity of the juice.

Hydrometers and Saccharometers.

Another method for readily determining the specific gravity of liquids is by means of the hydrometer or saccharometer, of which there are several kinds.

The principle upon which all of these instrument are constructed is, that whenever a body floats in any liquid, it displaces exactly a volume of that liquid equal in weight to the floating body.

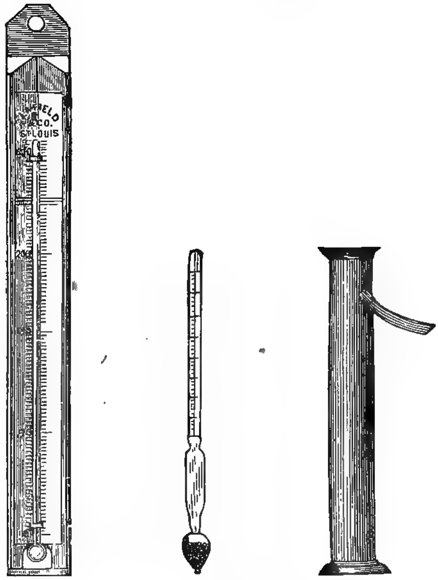
These hydrometers are glass bulbs, with a long, slender spindle, made by means of a little mercury at the lower end to maintain an erect position in the liquid. The lighter the liquid the deeper the instrument sinks, and the heavier the liquid the more of the spindle appears above the liquid. Within the glass spindle is a scale, so that a glance enables the operator to determine the specific gravity or density. For convenience, the scale is such as to enable the operator to determine either the specific gravity or per cent of any substance presumed to be present, etc.; and therefore these instruments have been prepared with scales adapted to any special purpose. We will explain those only which are in use for the determination of saccharine liquids. These are:

The scale of Beaumé, which is determined by marking as 0 the point on the spindle of the hydrometer to which it sinks when floating in pure water, and as 15° the point to which it sinks in a solution of 15 parts by weight of salt in 85 of water. The interval between these points is divided into 15 equal parts, and the scale is continued to any number of degrees beyond.

The scale of Brix, or Balling, as it is also called, gives the per cent of sugar present in any given solution; for example, a solution marking 10° Brix contains 10 per cent of sugar, etc.

The scale of Twaddle is graduated in such a manner that the number of degrees given, multiplied by 5 and added to 1000, will give the specific gravity, as compared with water taken at 1000. Thus: 10° Twaddle=1050 specific gravity.

To convert Beaumé degrees into specific gravity, divide 144 by 144 less the degrees of Beaumé; thus, 17° Beaumé equals 144 divided by 144 less 17—that is, 1.133.



1. 2. 3. 4.

Plate XLVIII.

No. 1. Thermometer.
No. 2. Saccharometer.
No. 3. Test cup for using saccharometer.
No. 4. Proof glass.

The above represents the thermometer, saccharometer, etc., which are generally used for the determination of temperature and specific gravity. A better form of thermometer than above represented is a plain glass stem, with bulb containing the mercury and the scale engraved upon the glass.

Comparison of different Hydrometers.

It has been thought best to here append a table which shall show the comparative values of the different scales. It is always preferable to use a hydrometer which shows the actual specific gravity of the juice, but those who have either the Beaumé or Brix hydrometers can, by use of this table, make them answer every purpose. It will be noticed that the specific gravity 1.066, which was recommended as the proper indication that the juice was in a workable condition, corresponds exactly with 16° Brix and 9° Beaumé.

SPECIFIC GRAVITY EQUIVALENTS OF THE BRIX AND BEAUMÉ SCALES.

Specific gravity.	Degree Brix.	Degree Beaumé.	Specific gravity.	Degree Brix.	Degree Beaumé.	Specific gravity.	Degree Brix.	Degree Beaumé.
1.000	0.	0.0	1.094	22.5	...	1.203	44.5	...
.002	.5	...	.097	23.	...	.206	45.	...
.004	1.	...	.099	23.5	13.0	.208	45.5	...
.006	1.5	...	.101	24.	...	.211	46.	25.0
.008	2.	1.0	.103	24.5	...	.214	46.5	...
.010	2.5	...	.106	25.	...	.216	47.	...
.012	3.	...	.108	25.5	14.0	.219	47.5	...
.014	3.5	2.0	.111	26.	...	.222	48.	26.0
.016	4.	...	.113	26.5	...	.225	48.5	...
.018	4.5	...	.115	27.	15.0	.227	49.	...
.020	5.	...	.118	27.5	...	.230	49.5	27.0
.022	5.5	3.0	.120	28.	...	.233	50	...
.024	6.	...	.123	28.5	...	.236	50.5	...
.026	6.5	...	.125	29.	16.0	.238	51.	...
.028	7.	4.0	.127	29.5	...	.241	51.5	28.0
.030	7.5	...	.130	30.	...	.244	52.	...
.032	8.	...	.132	30.5	...	.247	52.5	...
.034	8.5	...	.134	31.	17.0	.250	53.	...
.036	9.	5.0	.137	31.5	...	.252	53.5	29.0
.038	9.5	...	.139	32.	...	.255	54.	...
.040	10.	...	.142	32.5	...	.258	54.5	...
.042	10.5	...	.144	33.	18.0	.261	55.	...
.044	11.	6.0	.147	33.5	...	.264	55.5	30.0
.046	11.5	...	.149	34.	...	.267	56.	...
.048	12.	...	.152	34.5	19.0	.269	56.5	...
.050	12.5	7.0	.154	35.	...	.272	57.	...
.053	13.	...	.157	35.5	...	.275	57.5	31.0
.055	13.5	...	.159	36.	...	.278	58.	...
.057	14.	...	.162	36.5	20.0	.281	58.5	...
.059	14.5	8.0	.164	37.	...	.284	59.	...
.061	15.	...	.167	37.5	...	.287	59.5	32.0
.063	15.5	...	.169	38.	...	.290	60.	...
.066	16.	9.0	.172	38.5	21.0	.293	60.5	...
.068	16.5	...	.174	39.	...	.296	61.	...
.070	17.	...	.177	39.5	...	.299	61.5	33.0
.072	17.5	...	.179	40.	22.0	.302	62.	...
.074	18.	10.0	.182	40.5	...	.305	62.5	...
.076	18.5	...	.185	41.	...	.308	63.	34.0
.079	19.	...	.187	41.5	...	.311	63.5	...
.081	19.5	...	.190	42.	23.0	.314	64.	...
.083	20.	11.0	.192	42.5	...	.317	64.5	...
.085	20.5	...	.195	43.	...	.320	65.	35.0
.088	21.	...	.198	43.5	...	.323	65.5	...
.090	21.5	12.0	.200	44.	24.0	.326	66.	...
.092	22.	...						

Of course the reader will understand that the hydrometer, with either of the above scales, does not indicate necessarily the presence of sugar in a solution, but simply the relative weight of a certain volume of any liquid, as compared with the weight of the same volume of water. But, as will be seen by the preceding tables, in which the analyses of a very large number of sorghum and maize juices are given, together with the specific gravities, it is established as true, beyond question, that the specific gravity of any freshly expresed juice of either sorghum or maize, will enable one to tell its composition within very narrow limits. It is to be remembered, however, that this is only true of the freshly expressed juice. From cane, which has suffered in deterioration, either from having been cut a long time before pressing or

from the effects of a frost and subsequent warm weather—in such cases the specific gravity does not necessarily give any indication as to the composition of the juice.

This is a matter of such extreme practical importance, that the following results may be considered with interest.

In 1881, there were received at the Department of Agriculture, at Washington, several lots of sorghum-cane, which had been cut several days before they were delivered. The juices from these cane proved to be in a very surprising and abnormal condition, and their analyses are worthy of careful consideration. They were as follows:

JUICES FROM SORGHUMS CUT SEVERAL DAYS BEFORE GRINDING.

Dates.	Polarization.	Sucrose.	Glucose.	Specific gravity.	Solids.
September 27	.07	3.75	10.85	1.063	2.80
	.00	3 66	11 69	1 069	3 07
September 28	.00	2 30	13.25	1 070	2.48
September 30	1.04	5.16	10.78	1.072	2.53
October 3	1 05	2.62	10.45	1 059	2.41
October 4	.70	2.67	11.94	1.067	1.51
Average	.48	3.36	11 49	1.067	2.47

We have, then, as the average of the six juices, an amount of sucrose as indicated by the polariscope only 14.3 per cent of the amount shown to be present by analysis. We have also a specific gravity of 1.067, which indicates, as the average of a large number of analyses of normal juices, a juice of the following composition, viz:

	Per cent.
Specific gravity	1.067
Sucrose	11.80
Glucose	1.99
Solids	2.87

It will be seen that this composition resembles the average of the above six, except in this, that the sucrose and glucose appear to have changed places, the sum of the two being in one case 13.79 per cent, in the other 14.85 per cent.

Now, in over 4,000 separate analyses of sorghum juices from canes recently cut, there has never been found even one which approximated the composition of the average of these six juices above given.

In no case has the polariscope approximately differed so widely from the results of analysis as in these, for the average results of the polariscope, as compared with the results of analyses of all the juices analyzed, gave 96 per cent of the analytical result, while these contain but 14.3 per cent. The conclusion, then, is irresistible, that these juices are wholly abnormal, and are so through the inversion of the sucrose which existed in the plant, since the average of all the analy-

ses made have demonstrated, that if the total of glucose and sucrose in a juice is 14 or 15 per cent of the juice, at least 12 or 13 per cent of this had existed in the plant as sucrose. If not present upon analysis, it must have suffered inversion—as in this case was easily rendered probable by the stalks having been cut some days before they were worked up in the mill.

TABLES OF SPECIFIC GRAVITY OF SORGHUM JUICES AND THEIR COMPOSITION.

In the following tables are given average results obtained by the analysis of sorghum juices of different specific gravities, during the years 1879, 1880, 1881, 1882.

These give the average results of all the juices analysed, being several thousand, obtained from over one hundred distinct varieties of sorghum, and for four successive years, so that the average results can not but be accepted as of almost absolute accuracy.

In 1879, the number of varieties under examination were but four, and the number of analyses comparatively few, also the method for the correct determination of specific gravity and composition of the several juices not so well established as in the later years, but as confirming the general fact that the specific gravities will enable one to determine the composition of his juice, the results for 1879 are also given.

That such tables are of the greatest practical value to the manufacturer of sugar or syrup, is obvious.

By reference to them, the sugar-boiler can determine quite accurately the composition of any juice of which he knows the specific gravity. Although the varieties differ somewhat among themselves in the composition of the juice for the same specific gravity, still these differences are not so great as to be of much practical importance.

In examining these tables, it should be remembered that the results are valuable in proportion to the number of analyses from which each figure has been derived; therefore, while the figures derived from a small number of analyses are true for the particular canes examined, it is probable that a larger number of determinations would somewhat modify the results. If only those figures are examined which are based on ten or more analyses, it will be seen that the recorded results are very seldom exceptional.

Among other points shown by these tables, the following are important:

1st. The amount of juice obtained seldom falls below 60 per cent

of the weight of the stripped stalks; this percentage does not vary greatly throughout the season.

2nd. The amount of crystallizable sugar (sucrose) in the juice, is at first little over 1 per cent, but it regularly increases with the increase of specific gravity. No one relationship is more evident than this close correspondence between the increase of specific gravity and percentage of sucrose in the juice; the average increase of sucrose for an increase of .001 in specific gravity (between 1.030 and 1.086), is 0.233 per cent. The following shows the average increase of cane sugar corresponding with an increase of .001 *in specific gravity of the juice:*

Between 1.030 — 1 039 = .164 per cent sucrose.
Between 1.040 — 1.049 = .167 per cent sucrose.
Between 1.050 — 1 059 = .229 per cent sucrose.
Between 1.060 — 1.069 = 250 per cent sucrose.
Between 1.070 — 1.079 = .142 per cent sucrose.
Between 1.080 — 1.086 = 164 per cent sucrose.

3rd. It is a noticeable fact that the "solids not sugar" increase regularly, and with almost the same rapidity that the glucose diminishes. Thus, for the specific gravities between 1.030 and 1.086, the average percentage of glucose is 2.84, and of solids not sugar 2.71, while the actual loss of glucose is 2.76 per cent, and the actual gain of solids not sugar is 2.77 per cent. From the small number of ash determinations (34), it appears that the average percentage of ash in sorghum juice amounts to 1.07 per cent; hence it appears that a loss of 2.76 per cent of glucose is apparently counterbalanced by a gain of 1.70 per cent of organic solids not sugar, the ash varying but slightly. These figures are subject to future revision, when a much larger number of ash determinations may render it possible to draw conclusions with greater safety.

One point, however, seems to be strongly suggested, namely, that the decrease in glucose bears a much closer relationship to the increase of organic solids not sugar, than to the increase of crystallizable sugar. In other words, it seems at least possible that the commonly accepted idea that cane sugar is formed in plants only through the intervention of glucose, may be a mistaken idea. This point is a very interesting one, and worthy of careful study in the future.

4th. The percentage of total solids regularly increases, with a few exceptions, with the increase of specific gravity; the average increase for each gain of .001 in specific gravity, is 0.17 per cent of total solids.

5th. Experience has shown that the percentage of crystallizable sugar in the total solids of the juice should exceed 70, in order that good results may be had. See Table of Averages for 1880.

An inspection of these tables indicates that these juices attained that

percentage (see column headed "Available sugar") when the specific gravity 1.066 was reached, and this per cent was maintained, and even exceeded, until the specific gravity 1.086 was passed. After this the per cent is somewhat variable, because specific gravities above 1.086 were not attained until quite late in the season, when the plants had nearly or quite ceased growing; also, the number of experiments for these higher specific gravities was smaller than for the lower figures. It is safe to say that the profitable working period for sorghum canes begins when the juice attains the specific gravity 1.066, and continues until the specific gravity 1.086 is reached and frequently even longer. During this period, the canes examined furnished on an average 61.9 per cent of juice from the stripped stalks. A good mill should furnish not less than 60 per cent on the large scale. Several manufacturers are willing to contract for mills to furnish 65 per cent.

6th. On the supposition that a good mill, yielding at least 60 per cent of juice from the stripped stalks, is used, the amount of sugar which should be obtained from 100 pounds of stalks, is found by referring to the figures in the last column corresponding with the specific gravity of the juice obtained. For example, each 100 pounds of stripped stalks, the juice from which has the specific gravity 1.073, should actually furnish 7.7 pounds of cane sugar.

Specific Gravity Tables of Juices of Sorghum.

In these tables the average result in percentage of juice obtained, the percentage of the several constituents of the juice, the available sugar calculated as the difference between the sucrose and the sum of the solids not sucrose, the exponent of purity, by which is meant the percentage of sucrose in the total solids of the juices, and the available sugar calculated from this "exponent," as also the number of analyses made, is shown for each degree of specific gravity:

AVERAGE RESULTS OF ANALYSES OF SORGHUM JUICES AT DIFFERENT SPECIFIC GRAVITIES.

1879.

No. of analyses.	Specific gravity.	Glucose.	Sucrose.	Solids.	Available sugar.	Specific gravity.	Glucose.	Sucrose.	Solids.	Available sugar.	No. of analyses.
1	1031	3.40	2.40	2.60	......	1061	4.03	8.90	.96	3.91	3
1	2	4.10	1.80	1.04	......	2	......	......	......	......	....
1	3	5.90	1.00	.00	......	3	5.90	5.80	.42	......	1
...	4	......	......	......	......	4	4.03	10.17	.00	6 14	3
....	5	......	......	......	......	5	6.60	6.90	1.94	......	2
...	6	...	......	......	......	6	3.15	11.75	.67	7.93	2
2	7	5.71	1.95	.00	......	7	4.60	7.10	2.30	.20	1
...	8	......	......	......	......	8	1.10	11.80	3.44	7.26	2
1	9	3.70	4.60	0.90	......	9	......	......	......	......	....
1	1040	4.90	4.00	.00	......	1070	3.00	12.35	1.23	8.12	8
1	1	5.20	2.70	.93	......	1	2.78	9.08	5.43	.87	4
1	2	5.00	3.40	.06	......	2	2.15	12.55	1.29	9.11	2
1	3	4.20	4.10	67	......	3	1 60	12.30	3.48	7.22	3
2	4	5.36	4.00	.61	......	4	1.60	14.21	1.36	11 25	7
1	5	5.01	4.40	.03	......	5	2.73	13.20	1.75	8 72	3
2	6	4.95	4.40	.63	......	6	1.73	13.15	3.45	7.97	4
2	7	4.50	4.90	1.37	......	7	1.38	13 84	2.46	10 00	10
4	8	3.75	5.08	1.54	......	8	1.53	13.79	2.74	9.52	7
...	9	......	......	......	......	9	1.51	13.47	3.72	8 24	9
2	1050	6.00	4.40	1.33	......	1080	1.02	14.16	2.48	10 66	12
....	1	......	......	......	......	1	1.40	13.79	3.62	8.77	15
1	2	7.10	5.40	.51	......	2	1.40	14.75	2.32	11.03	11
...	3	......	......	......	......	3	1.10	15 17	3.62	10.45	3
3	4	6.79	5.53	1.03	......	4	2.15	14.55	3.11	9.26	2
1	5	4.90	7.40	.95	1.55	5	1.20	15.06	3.31	10.55	5
1	6	3.50	7.90	.81	3.59	6	2.35	12.05	5.46	4.24	2
5	7	3.52	8.12	1.84	2 76	7	1.93	14.43	3.78	8.72	3
....	8	......	......	......	......	8	2.30	16 80	.00	14.50	1
1	9	2.90	9.40	1.01	5.59	9	......	......	......	......	....
1	1060	2.40	10.60	.92	7.28	1090	......	......	......	......	....
....	......	......	......	......	......	1	......	......	......	......	....
....	......	......	......	......	......	2	.90	17.70	3.09	13.71	1

AVERAGE RESULTS OF ANALYSES OF SORGHUM JUICES AT DIFFERENT SPECIFIC GRAVITIES, 1880.

Specific gravity.	Per cent of juice.	Per cent of glucose.	Per cent of sucrose.	Per cent of solids not sugar.	Total solids in juice.	Exponent.	Available per cent sucrose in juice.	Available per cent sucrose in stripped stalks at 60 per cent juice.	No. of analyses.
1.019	61 32	.67	2.20	3 12	5.99	36.73	.81	.48	1
1.021	58.30	3.91	.54	.68	5 13	10.53	.06	.04	2
1.022	69.04	3.06	1 46	1.11	5 63	25 93	.38	.23	1
1.023	47 36	3.27	1.15	1.29	5 71	20.14	.23	.14	3
1.024	60.49	3.85	1.02	1.73	6.60	15.45	.16	.10	1
1.026	62.78	4.04	.98	.91	5.93	16.53	.16	.10	1
1.027	57.08	3.41	2.09	1.61	7.11	29 40	.61	.37	3
1 028	46.61	3.98	1.79	2.34	8.11	22 07	.40	.24	8
1.029	57.72	4.34	1.55	1.53	7.42	20 89	.33	.20	6
1.030	45.44	3.98	2.36	1 82	8 16	28 92	.58	.35	11
1.031	56 01	3.82	2.66	1.58	8 06	33.00	.88	.53	12
1.032	60.97	3.95	2 16	2.05	8 16	26 47	.57	.34	17
1.033	60.13	4.52	2.26	1.78	8 56	26.40	.60	.36	28
1.034	66.96	4.24	2.50	1 93	8 67	28 84	.72	.43	13
1.035	60.22	4.11	3.29	1.98	9 38	35.08	1 15	.69	23
1.036	64.28	4.56	3 12	1.59	9.27	33 66	1.05	.63	23
1 037	60.12	4.42	3.56	1.75	9.73	26.59	1 30	.78	25
1 038	61.37	4.43	3.43	1.88	9.74	35.22	1 21	.73	21
1.039	61.30	4.14	4.00	1.85	9 99	40.00	1.60	96	25
1 040	62.78	3 94	4.41	1.77	10.17	43 36	1 91	1 15	18
1 041	62.41	4 21	4.30	1.92	10 43	41 23	1.77	1.06	26
1.042	59.40	4.13	4.69	1.91	10 73	43.71	2 05	1.23	23
1.043	64.72	4.26	4 95	1.92	11 13	44 48	2.20	1 32	22
1.044	63 98	3.79	5.23	2.17	11 19	46.74	2 42	1.45	17
1.045	64.54	3.87	5 51	2.19	11.47	48 04	2 65	1 59	24
1.046	64.34	3.76	5.72	2.10	11.58	49 34	2.82	1 69	30
1.047	65 03	3.43	6 28	2.15	11 86	52 95	3 33	2.00	31
1.048	65.18	3.99	6.08	2.03	12 10	50 25	3.06	1.84	36
1 049	62.88	3.62	6.34	2 23	12.19	52.01	3.30	1.98	37
1.050	66.17	3.32	6 99	2 29	12 60	55.48	3 88	2.33	48
1.051	62.81	3.12	7.18	2 26	12 56	57.17	4.10	2 46	42
1.052	64.36	3.18	7.64	2 46	13 28	57 61	4 40	2 64	43
1.053	63.95	3.42	7.58	2 31	3 31	56.95	4 32	2 59	43
1.054	63.33	3.12	7.74	2 27	13 13	58 95	4 57	2.74	49
1 055	65.66	3.38	8 12	2.24	13.74	59.09	4.80	2 88	55
1.056	63.66	2.96	8 61	2.40	13.97	61 63	4 92	2.95	52
1.057	62.74	2.99	8 90	2.34	14.23	62.54	5.57	3.34	56
1.058	64 10	2.78	9 18	2 53	14.49	63 35	5.82	3.49	76
1.059	63 93	3.05	9.28	2 44	14.77	62 90	5.84	3.50	53
1.060	63 15	2.65	9 80	2.67	15.12	64 81	6.35	3.81	100
1.061	64 86	2.73	9 88	2.75	15 36	64 32	6.36	3.82	76
1.062	63 35	2.51	10.24	2.77	15 52	65 98	6 76	4.06	73
1.063	64 74	2.65	10 16	2.95	15.76	64.47	6 55	3 93	84
1.064	63 48	2.43	10.64	2. 5	16.02	66.42	7 07	4.24	64
1.065	61.08	2.07	11.19	2.85	16.11	69.46	7 77	4.66	81
1.066	63.58	2.08	11.46	2.72	16 26	70.48	8.08	4.85	74
1.067	60.98	1 99	11 80	2.87	16.66	70.83	8.36	5.02	69
1 068	63.25	1.97	11.84	3.00	16.81	70.43	8 34	5.00	56
1.069	61.15	1.81	12 30	3 05	17.16	71.68	8.82	5.29	75
1.070	63.45	1.84	12 59	3.00	17 43	72 23	9.09	5.45	82
1.071	62.37	1.81	12.54	3.26	17 61	71 21	8 93	5 36	89
1.072	61.81	1.68	12 94	3.21	17 83	72 58	9.39	5.63	82
1.073	62.46	1.85	12 83	3 20	17.88	71.76	9 19	5.51	75
1.074	61.44	1.69	13.22	3 37	18.28	72 32	9.56	5.74	75
1 075	61.78	1.71	13.47	3.37	18.55	72.62	9.78	5.87	67

AVERAGE RESULTS OF ANALYSES OF SORGHUM JUICES, ETC., 1880.—*Continued.*

Specific gravity.	Per cent of juice.	Per cent of glucose.	Per cent of sucrose.	Per cent of solids not sugar.	Total solids in juice.	Exponent.	Available per cent sucrose in juice.	Available per cent sucrose in stripped stalks at 60 per cent juice.	No. of analyses.
1.076	61.49	1.47	13.66	3.54	18 67	73.16	9.99	5 99	68
1.077	60 41	1.62	13 75	3.58	18 95	72.56	9.98	5.99	45
1.078	61.18	1.50	13.88	4.04	19.42	71.47	9.92	5.95	52
1.079	60.80	1.51	14.01	3.67	19.19	73 01	10 23	6.14	46
1.080	60 00	1.57	14.01	3 74	19.32	72.52	10.16	6.08	41
1.081	60.58	1.43	14 24	4.10	19 77	72 03	10.26	6.16	25
1.082	60.47	1.14	15 06	4 05	20 25	74 37	11.20	6.72	25
1.083	59.71	1.50	14 71	4.23	20 44	71.97	10.59	6.35	20
1.084	59 27	1.48	14 84	4.13	20.45	72.56	10.77	6.46	17
1.085	60.07	1.22	15.14	4.56	20 92	72 37	10 96	6.58	12
1.086	58 74	1.22	15 65	4 59	21.46	72 92	11.41	6.85	14
1.087	53.68	2.35	13.83	4 38	20.56	67.26	9.30	5.58	3
1.088	59.08	1.38	15 32	4 69	21.40	71 59	10 87	6.52	9
1.089	57.72	.80	16.25	6.32	23.37	69.53	11 30	6.78	1
1.090	55.57	1.19	15 87	4.78	21 84	72.66	11.53	6.92	3
1.092	54.55	2.75	14.76	4.70	22.21	66.45	9.81	5.89	1

SORGHUM JUICES, 1881.

Specific gravity.	Per cent of juice.	Per cent of glucose.	Per ct. of sucrose.	Per ct. of solids not sugar.	Per cent of Polarization.	Per ct. of available sugar.	No. of analyses.
1.012	65 67	1.11	.26	3.17	....	—4 02	1
1.014	66.08	1.69	.43	2.66	....	—3 92	3
1.015	63 84	1.64	.64	2.56	....	—3 56	5
1.016	64 91	1.57	.26	2.27	....	—3 58	7
1 017	62 10	2.33	.43	2 50	....	—4.40	8
1 018	58 96	1.66	.68	2.19	....	—3 17	5
1.019	64 97	2.55	.46	2.79	....	—4.88	9
1 020	66 60	2.58	.90	3.10	....	—4 78	18
1 021	65 26	2 80	.49	3.25	....	—5 56	11
1 022	64 53	2 29	.99	3.20	....	—4 50	7
1.023	67 92	3.06	.94	3.92	....	—6.02	15
1 024	69 00	3.24	.80	2 72	....	—5.16	13
1 025	65 91	2 68	1.49	3.26	....	—4.45	13
1 026	68.25	3 21	1 61	2.39	....	—3.99	17
1.027	67 87	3.12	1.44	2 85	....	—4 53	14
1 028	67 37	3.55	1.38	3 66	....	—5 83	9
1 029	66 57	3 64	1 63	3 18	....	—5.19	11
1 030	65 89	2 88	2 12	2.45	1 78	—3 21	8
1.031	59 56	2 68	2 69	2 94	2.01	—2 93	6
1 032	68 27	3.89	1.79	2 60	2.15	—4.70	12
1 033	68 40	3.30	3 08	3 05	2.89	—3 27	8
1 034	64 83	3.41	2 68	2 81	2 95	—3 54	13
1.035	70.12	4 32	2 70	2.75	2 92	—4 37	10
1 036	66 80	3 95	2 97	3.19	1 28	—4 17	10
1 037	64 16	3 22	4 69	3 73	3 02	—2 26	8
1.038	59 97	3.26	3 39	2 49	3.83	—2 36	9
1.039	66 98	3 93	4 10	2 15	4.28	—1 98	12
1 040	67 18	4 02	4 39	2.44	3.93	—2 07	14
1.041	66 32	3 41	5.21	3.16	4.36	—1.36	11
1.042	64.84	3.14	5.14	2 68	4.82	— .68	12

SORGHUM JUICES, 1881.—*Continued.*

Specific gravity.	Per cent of juice.	Per cent of glucose.	Per ct. of sucrose.	Per ct. of solids not sugar.	Per cent of polarization.	Per ct. of available sugar.	No. of analyses.
1.043	66.17	3.76	4.81	3.22	4.41	—2.17	13
1.044	63.54	3.59	5.11	3.08	4.33	—1.56	16
1.045	68.42	3.86	5.54	2.51	5.46	— .83	12
1.046	62.99	3.29	5.31	2.92	5.56	— .90	20
1.047	62.75	2.52	6.33	3.07	6.77	.74	18
1.048	65.97	3.48	6.01	3.33	5.11	— .80	12
1.049	67.01	3.66	6.85	3.42	6.78	— .23	14
1.050	64.07	3.47	6.66	3.03	5.90	.16	16
1.051	61.58	3.17	6.88	3.02	6.35	.61	16
1.052	63.62	3.17	7.19	3.41	6.74	.61	16
1.053	68.33	3.05	7.81	2.89	7.50	1.87	14
1.054	64.40	3.08	8.08	3.19	7.69	1.81	15
1.055	57.71	3.34	7.35	3.52	7.02	.49	16
1.056	61.93	2.79	7.18	3.75	7.78	.64	15
1.057	61.20	3.12	8.45	3.00	7.81	2.33	10
1.058	59.47	2.57	8.44	3.37	7.85	2.50	18
1.059	62.83	3.58	8.54	2.82	8.08	2.14	12
1.060	63.33	3.22	10.16	2.58	9.72	4.36	5
1.061	62.62	3.38	9.30	3.20	9.34	2.72	13
1.062	63.15	2.36	10.76	3.08	9.66	5.32	13
1.063	62.34	2.13	11.44	2.82	10.46	6.49	11
1.064	60.26	2.45	10.49	3.40	9.67	4.64	20
1.065	62.98	2.74	10.82	3.16	10.05	4.92	22
1.066	62.43	2.42	11.38	3.06	10.79	6.90	20
1.067	59.22	1.83	11.51	3.19	11.14	6.49	19
1.068	58.35	1.71	11.75	3.41	11.19	6.63	22
1.069	61.24	1.97	12.10	3.46	11.56	6.67	22
1.070	57.60	2.57	12.24	2.86	11.53	6.81	21
1.071	59.68	1.86	12.53	3.60	11.89	7.07	24
1.072	60.22	1.87	13.06	3.33	12.46	7.86	22
1.073	59.80	2.15	13.09	3.00	12.87	7.94	30
1.074	59.28	1.56	13.45	3.75	13.36	8.14	21
1.075	59.35	2.05	13.58	3.48	13.09	8.05	39
1.076	60.47	1.77	13.96	3.52	13.66	8.67	30
1.077	58.58	1.41	14.58	3.49	13.07	9.68	31
1.078	58.71	1.42	14.53	3.42	14.00	9.69	28
1.079	59.47	1.18	14.86	3.50	14.65	10.18	20
1.080	58.08	1.38	14.92	3.59	14.47	9.95	24
1.081	57.75	1.73	14.79	3.71	14.17	9.35	19
1.082	58.77	1.28	15.88	3.37	15.41	11.23	35
1.083	59.06	1.56	15.96	3.47	15.24	10.93	31
1.084	58.64	1.85	15.93	3.77	15.27	10.31	14
1.085	61.15	.88	16.14	4.39	15.77	10.87	20
1.086	58.03	1.31	16.58	3.41	15.98	11.86	16
1.087	57.55	1.11	17.15	3.89	16.18	12.15	18
1.088	58.41	1.59	17.45	3.96	15.83	11.90	16
1.089	59.56	1.48	17.54	3.85	15.79	12.21	17
1.090	59.64	1.24	17.79	3.06	15.79	13.49	9
1.091	53.63	1.50	17.82	4.48	16.45	11.84	12
1.092	53.25	.91	18.48	5.23	…	12.34	3
1.093	56.52	3.62	18.09	2.59	17.00	11.88	3
1.094	55.29	1.03	18.51	3.87	18.62	13.61	2
1.095	59.51	.95	19.58	2.75	…	15.88	1
1.096	…	…	…	…	…	…	…
1.097	…	…	…	…	…	…	…
1.098	54.51	1.37	18.60	3.46	18.70	13.77	2

AVERAGE RESULTS OF ANALYSES OF SORGHUM JUICES AT DIFFERENT SPECIFIC GRAVITIES, 1882.

No. of analyses.	Specific gravity.	Per cent juice.	Per cent glucose	Per cent sucrose.	Per cent solids not sugars.	Polarization.	Per cent available sugar.
1	1.015	59.51	0 25	0.51	2.78	0 55	—2.52
1..........	20	59 26	0.26	1.41	2.89	1.26	—1 74
1..........	26	57.34	2 02	1.70	2 46	1 81	—2 78
2..........	27	62.23	1 27	2.63	2 38	2 19	—1 62
1..........	28	55.33	0 39	3 05	2 86	2.16	—0.20
2	1.030	51 84	1.38	3 43	2 28	3.21	—0 22
1..........	31	71.30	1 10	3.00	2.76	3.04	—0 86
2	32	56.45	1.86	3 39	3 30	....	—1.77
2	33	61 45	1 37	4 25	2.76	3.74	—0.02
3	34	54.16	1 30	3.78	2.79	3.69	—0 32
2	35	66 45	3.36	3 03	1 81	3.10	—2 14
1..........	36	62.36	3 91	4 13	1.58	....	—1.36
2..........	37	65.60	3.49	3.55	2 12	3.55	—2 06
3..........	38	64.39	2 41	4 95	1 87	4.85	0.66
5	39	61 91	1.94	4 47	2.73	4.74	—0 19
2	1.040	67.63	3.49	4 93	1.30	4 42	0.15
5..........	41	62.35	2 79	4.84	2.42	4.11	—0.37
[illegible]..........	42	59.51	3.19	4.47	2.33	4.52	—0.93
3	43	50.30	1.13	5 43	3 63	5 59	0.67
3	44	65.04	3 51	5.82	1 65	5.06	0 66
6	45	55.90	1 88	6.44	2.66	5.95	1.91
9	46	53.86	2 91	6 09	2.30	5.43	0.88
7	47	62.80	2.98	6.22	3 15	6 29	0 09
11.........	48	60.70	2 34	7 02	2.66	7.05.	2 02
9..........	49	56.16	3.00	6.57	2 76	5.99	0.81
11..........	1.050	54.94	2.45	6 86	2.83	6.64	1 59
14..........	51	57.74	2 53	7.83	2 38	7.05	3.17
17..........	52	56 16	1.69	8 23	2 84	7.92	3.69
19..........	53	55.58	2.33	8.19	2.48	7.85	3 38
18..........	54	58 55	2.29	8.19	2.42	7.92	3.47
21..........	55	57 38	2.75	8 09	2.32	7.72	3.12
30	56	58 19	1.99	8 58	2 78	8 54	3 80
35..........	57	57 71	1.75	8 91	2.88	8.90	4.29
25..........	58	57 70	1 98	9.31	2.65	9.39	4.68
18..........	59	56.85	1 78	9 45	3.02	9 40	4 64
28	1.060	51.18	2 02	9.84	2 74	9.80	5.24
25..........	61	55.39	1.98	9 75	2.83	9 95	4 53
29..........	62	55 87	1 87	10 26	2.61	10.08	5 83
30...	63	58.44	1.66	10.59	2 87	10.50	6.04
38	64	59 11	1 46	10.73	2.83	10.72	6.83
30..........	65	56.38	1.62	10 97	2 91	10.96	6.44
36..........	66	56.62	1.47	11.32	2 84	11.19	6.73
36..........	67	58.81	1.35	11 50	3.02	12.29	7.12
31...	68	59.67	1.54	11 80	2.71	11.79	7.55
53..........	69	58.37	1.50	12.19	2.73	12.06	7.95
29..........	1.070	58 13	1.40	12.23	3.03	12.13	7.94
33	71	57 38	1 07	12.75	3 09	12 86	8.29
40..........	72	57 08	1.40	12 76	2.87	12 57	8 50
46..........	73	58 12	1.22	13.18	2.91	13 02	9 05
37....	74	56.18	1.57	13.09	2 58	12.90	8.67
31..........	75	57.49	1.10	13.50	3.27	13.41	9.13
32..........	76	56 17	1.36	13.39	2 89	13.15	8 82
26	77	57 59	1.12	13 76	3.27	13.79	9 38
24	78	55.98	1 40	13.71	3.08	13.69	9.23
18	79	55 39	1.00	14.16	3.17	14 06	9 99
14..........	1.080	53.25	0 97	14.53	3.13	14 38	10 39
9..........	81	53.49	1.03	14 52	2.98	14.53	10.51
10..........	82	52 68	1.38	14.64	2.78	13.23	10.44
12..........	83	48.45	1.55	14.24	3.15	13.88	9 56
2	84	52.29	1 01	15.30	3.12	14.72	11.18
5..........	85	47.94	1.63	14.29	3.47	14 06	9.20
1..........	86	52 00	0.74	15.68	3.41	15 44	11.53
1.........	87	48 88	0 62	15.36	3.78	15 57	10 96
1..........	89	42.16	1.95	14.96	3.16	13.94	9.85
1..........	1.090	42.50	2 03	15 57	2 94	15 12	10.60
1..........	91	43.40	2.53	14.98	3.00	13 81	9 45
1..........	92	42.54	1.96	15 34	3 08	14.40	10.30
1..........	93	37.13	2.82	14.97	3.09	....	9.06
1..........	95	39.25	3 34	15.17	2.61	13.72	9.22
1..........	1.105	35.01	2.33	17.19	3.67	....	11.19

SPECIFIC GRAVITY OF MAIZE JUICES, AND THEIR COMPOSITION.

In the following tables, the average composition of juices of maize stalks, at each specific gravity, and obtained from a number of varieties in all, is given. It will be seen that the general results show that the composition of these juices also may be determined by their specific gravity.

MAIZE JUICES, 1880.

Specific gravity.	Per cent juice.	Per cent glucose.	Per cent sucrose.	Per cent solids not sugars.	Per cent available sugar.	No. of analyses.
1.019	37.83	1.19	1.95	1.13	—.37	1
1.020						
1.021	47.52	.34	1.77			1
1.022	54.97	.09	1.23	2.25	—1.11	1
1.023	45.96	.61	1.72	2.26	—1.15	1
1.024						
1.025	65.26	.76	3.21	2.17	.28	1
1.026	63.06	.72	2.64	2.74	—.82	2
1.027	58.78	.85	3.71	2.10	.76	2
1.028	55.75	1.93	3.39	2.02	—.56	1
1.029						
1.030						
1.031	64.53	1.26	3.32	2.37	—.31	3
1.032	61.93	1.51	3.16	2.31	—.66	1
1.033	63.29	1.46	4.53	2.29	.78	2
1.034	64.05	1.05	4.88	2.48	1.35	1
1.035	64.47	1.15	4.37	2.24	.98	2
1.036						
1.037	52.60	1.20	4.73	3.00	.53	3
1.038	58.65	1.99	4.79	2.23	.57	2
1.039	67.75	.42	6.16	3.00	2.74	1
1.040	61.42	1.32	6.24	2.43	2.49	3
1.041	59.57	1.45	6.20	2.59	2.16	7
1.042	57.58	1.80	5.90	2.62	1.58	4
1.043	62.94	1.80	6.35	1.94	2.61	2
1.044	60.32	1.95	6.71	1.76	3.00	2
1.045	60.97	1.82	7.17	1.90	3.45	2
1.046	61.67	1.80	7.72	2.04	3.88	3
1.047	58.52	1.32	8.17	2.75	4.10	7
1.048	56.55	1.81	7.08	2.80	2.47	4
1.049	63.57	1.08	7.96	2.92	3.96	3
1.050	63.63	1.02	9.18	1.74	6.42	2
1.051						
1.052	59.75	1.66	8.95	2.83	4.46	2
1.053	55.35	1.43	9.13	2.56	5.14	4
1.054	57.30	1.7[illegible]	8.01	3.51	2.74	4
1.055	47.81	1.04	9.13	3.61	4.48	4
1.056	55.02	1.00	9.58	2.81	5.77	3
1.057	56.71	1.28	9.02	3.65	4.09	11
1.058	57.29	1.33	9.49	2.75	5.41	5
1.059	58.39	1.36	9.85	3.99	4.50	8
1.060	53.45	.95	9.61	4.12	4.54	6
1.061	55.60	1.27	10.02	3.73	5.02	8
1.062	56.81	1.05	10.87	3.54	6.28	11
1.063	53.13	.93	10.27	3.78	5.56	6
1.064	52.55	.99	11.05	3.96	6.10	8
1.065	54.81	1.26	10.98	3.73	5.99	12
1.066	49.63	.93	10.81	4.10	5.78	6
1.067	46.93	1.12	11.33	4.21	6.00	6
1.068	57.20	.82	12.45	3.84	7.79	7
1.069	53.87	.60	12.54	4.39	7.55	1
1.070	48.27	.86	11.99	4.35	6.78	2
1.071	56.11	1.14	11.77	4.42	6.21	3
1.072	50.25	.77	12.14	4.43	6.94	4
1.073	49.76	1.12	12.95	3.04	8.79	3
1.074	58.90	.91	11.49	5.83	5.75	3
1.075	47.69	1.20	11.01	5.72	4.09	2
1.076	39.47	.68	11.45	6.18	4.59	1
1.077	57.63	.71	13.99	4.91	8.37	1
1.078						
1.079	55.11	.89	15.16	3.27	11.00	1

As to relative value of sorghum and maize juices of the same specific gravity, reference is made to page 443, where this point is discussed at length.

MAIZE JUICES, 1881.

Specific gravity.	Per cent of juice.	Per cent of glucose.	Per cent of sucrose.	Per cent of solids not sugar.	Per cent of polarization.	Per cent of available sugar.	No. of analyses.
1 014	69 10	1.17	.47	1.52	....	—2.22	1
1.015	75.75	1 69	.32	1.39	....	—2.76	2
1.016	65 70	1.36	.30	1.94	....	—3 00	3
1.017	68 28	2 02	.24	2 06	....	—3 84	4
1.018	63 90	2 08	.27	2.37	....	—4 18	4
1.019	65 92	1 89	.55	3.14	...	—4 48	3
1.020	63.39	2 77	.38	3.40	....	—5.79	4
1 021	65 83	2.55	.60	2.26	....	—4.21	4
1.022	66 39	3.35	.49	2.66	....	—5 52	4
1.023	62.70	3.10	.86	2 93	. ..	—5.17	6
1.024	65.43	2 53	1.50	2.85	....	—3.88	7
1.025	65.61	2 92	1.04	2.83	....	—4 71	6
1.026	66.97	3 10	1.04	3.11	....	—5 17	2
1.027	57.34	1 93	2.14	3.20	....	—2 99	3
1.028	60 76	2.93	1.50	3.31	....	—4.74	6
1.029	60 61	2.71	2 45	2.53	2.17	—2 79	9
1 030	56 57	2 54	4 31	2.38	3.24	— .61	6
1 031	57 51	2.91	2 69	2 76	2.08	—2.98	2
1.032	59.42	2.92	3 07	2.80	2 80	—2.65	4
1.033	58.62	3 30	2.82	2.51	2 29	—2.99	3
1 034	60.16	3 21	3 68	2.62	3 66	—2.15	3
1.035	51.00	2.41	4.08	2.65	3 45	— 99	6
1.036	56 95	2 98	3.76	2 95	4 53	—2.17	5
1.037	55 17	2.60	4 47	2.96	4.25	—1.09	4
1 038	61.47	3 07	4 16	1 63	3.72	— .54	3
1 039	56.33	2 51	5 50	2.11	5.08	.88	7
1 040	62.63	2 79	4.82	2 77	5.05	— .74	7
1.041	57 47	2 74	5.49	2 24	5 00	.51	8
1.042	54 63	2 43	5.56	2 93	5.37	.20	4
1.043	61.46	3 03	5.16	2 90	5.44	— .77	4
1 044	56 68	2 71	6.57	2 33	5 99	.53	5
1.045	53 22	2 99	6 97	2 96	6 39	.12	6
1.046	61.34	2 85	6.64	2 82	6.16	.97	2
1.047	56 94	2.60	7.45	1.50	7.42	3.35	3
1.048	54 38	2.44	7.61	2 46	6 08	2 71	3
1.049	61.02	2 49	8 89	2.10	7.51	4 30	5
1.050	57.71	2.73	7 81	2 47	7 54	2 61	6
1.051	57 30	2 08	8.27	3.14	7.20	3.05	2
1.052	54 90	3.20	8.24	2 81	7.58	2.23	1
1 053	56.75	2.75	9 10	2.10	8 66	4.25	3
1 054	71.39	2.92	7.64	3.86	7.52	.86	1
1.055	57.18	2 78	9 18	1.99	6 91	4.41	3
1 056	53.72	2 39	10 88	2.51	9 46	5.98	2
1 057	62 36	1 68	11 2t	1.76	10 22	7.77	3
1 058	55 47	2.54	10 45	2.19	10.25	5.72	2
1.059	58.78	2.27	11 01	1.76	10 52	6.98	2
1 060	53.31	2 12	10.62	2 44	10 58	6.06	3
1.061	56.07	1.99	11 92	1 85	10.65	8.08	5
1 062	53 49	2.30	11.44	3.46	11.39	5.68	4
1.963	.....	....	.....	....	.....	. ..	
1 064	53 14	1.29	12.94	1 88	12.37	9.77	1
1.065	53.90	2.05	11.92	2.36	11.40	7.51	2
1.066	.....	....	. .	....	....	. . .	
1.067	53.11	1.44	13.88	2.86	....	9.58	1
1.068	.....	....	....	....	....	....	
1.069	51.47	2.25	12.55	2.50	11.74	7 80	1
1 070	....	...	....	....	.....	...	
1 071	50 14	5 41	9.91	3.35	.....	1.15	1
1 072	....	...	.... .	...	. .	...	
1 073	54.89	1.75	13 59	2.19	.....	9.65	1

Average Results of Analyses of Sorghum Juices during their Working Period.

From what has been already said, it is clear that the best results in sugar or syrup can only be secured when the seed is fully matured, and when the specific gravity of the juices shall equal or exceed 1.066.

If now we average the results of those analyses of sorghum juices, the specific gravity of which exceeded 1.065, we find the results given in the following tables.

Although, for the greater part, the varieties under examination were entirely different, and, as will be seen by reference to the meteorological data given upon page 147, the several seasons were, in their climatic conditions, widely unlike, it will be found that the several tables give very closely accordant results; thus fully confirming the opinion that the character of the crop may be very closely ascertained by the specific gravity of the juice, both as to its value for sugar and syrup.

AVERAGE RESULTS FOR SORGHUM, 1879.

[Juices above 1.065 specific gravity,]

	Per cent.
Sucrose in juice	13.35
Glucose in juice	1.94
Solids not sugars in juice	2.79
Available sugar by difference	8.62
Exponent	73.8
Available sugar by exponent	9.85
Number of analyses, 117.	

AVERAGE RESULTS FOR SORGHUM, 1880.

[Juices above 1.065 specific gravity.]

	Per cent.
Juice obtained	60.22
Sucrose in juice	13.85
Glucose in juice	1.64
Solids not sugars in juice	3.85
Available sugar by difference	8.36
Exponent	71.7
Available sugar by exponent	9.93
Number of analyses, 1,127.	

AVERAGE RESULTS FOR SORGHUM, 1881.

[Juices above 1.065 specific gravity.]

	Per cent.
Juice obtained	58.51
Sucrose in juice	15.29
Polarization	14.34
Glucose in juice	1.62
Solids not sugars in juice	3.55
Available sugar by difference	10.12
Exponent	74.7
Available sugar by xponent	11.42
Number of analyses, 501.	

AVERAGE RESULTS FOR SORGHUM, 1882.

[Juices above 1.065 specific gravity.]

	Per cent.
Juice obtained	51.52
Sucrose in juice	14.00
Polarization	13.54
Glucose in juice	1.53
Solids not sugars in juice	3.06
Available sugar by difference	9 41
Exponent	75.3
Available sugar by exponent	10.54

Number of analyses, 513.

AVERAGE RESULTS FOR SORGHUM, 1879, '80, '81, '82.

[Juices above 1.065 specific gravity.]

	Per cent.
Juice obtained	56.75
Sucrose in juice	14.12
Polarization	13.94
Glucose in juice	1.68
Solids not sugars in juice	3 31
Available sugar by difference	9 13
Exponent	73.9
Available sugar by exponent	10.43

Number of analyses, 2,348.

From the above results it will be seen that, as the average of 2,348 analyses of over 100 varieties of sorghum, and during a period of four successive years, there was found in one ton (2,000 pounds) of sorghum by exponent 118.3 pounds of sugar available, and by difference 103.6 pounds; while in the several years the results were as follows:

AVAILABLE SUGAR FROM 2,000 POUNDS STRIPPED SORGHUM STALKS.

	By Exponent.	By Difference.
1879	111.7	97.8
1880	119.6	100.7
1881	133.6	118 4
1882	119.6	106 8
1879–82	118.4	103.6

It would appear, therefore, clearly established, as the result of all these analyses of nearly every variety of sorghum known, that, with our ordinary mills, we may secure from every ton of stalks, if worked at the proper time, at least 110 pounds of sugar; a result fully equal to the average secured from sugar-cane in Louisiana.

Average Results of Analyses of Maize Juices During the Working Period.

The following tables give the average results secured by the analyses of the juices of several varieties of maize in the years 1880, 1881.

If we include all the analyses of maize juices in which the specific

gravity exceeded 1.055 for 1880, there were made in all 118 analyses, with the following average results:

AVERAGE RESULTS FOR MAIZE, 1880.

[Juices above 1.055 specific gravity.]

	Per cent.
Juice obtained	53.43
Sucrose in juice	11.30
Glucose in juice	1.01
Solids not sugars in juice	4.12
Available sugar=sucrose—(glucose+solids)	6.17
Exponent	68.8
Available sugar calculated by exponent	7.77
Number of analyses, 118.	

AVERAGE RESULTS FOR MAIZE, 1881.

[Juices above 1.055 specific gravity.]

	Per cent.
Juice obtained	54.60
Sucrose in juice	11.72
Glucose in juice	2.27
Solids not sugars in juice	2.39
Polarization	10.86
Available sugar=sucrose—(glucose and solids)	7.06
Exponent	71.6
Available sugar calculated by exponent	8.39
Number of Analyses, 28.	

The available sugar from one ton (2,000 pounds) of maize stalks was, in 1880, by exponent method of estimation, 83 pounds, a difference between sucrose and other solids of 66 pounds; in 1881, from 2,000 pounds stalks, by exponent, 92 pounds, a difference of 77 pounds between sucrose and other solids.

The results by polarization of the above maize juices in 1881 was 92.6 per cent of the results obtained by analysis.

The Hydrometer and Ripe Seed Sufficient to Indicate the Proper Time for Working the Crop.

It will be seen, by reference to the preceding tables, that it is within the means of the common farmer to inform himself accurately as to the condition of his crop by simply examining the seed, and by the hydrometer learning the specific gravity of the expressed juice.

For each increase of .001 n specific gravity between 1048 and 1086, in the year 1880, there was an average increase (glucose excepted) in the several constituents of the juice of the several sorghums as follows:

	Per cent.
Sucrose	.251
Solids	.067
Available sugar	.257
Glucose ....minus	.073
Number of analyses, 2,186.	

In 1881, the increase for each .001 specific gravity was, in the average results for specific gravity, between 1052 and 1082:

		Per cent.
Sucrose		.305
Solids		.013
Available sugar		.354
Glucose	minus	.062

Number of analyses, 438.

The general average for the years 1879, 1880, and 1881, specific gravity between 1048 and 1080, was for each increase of .001 specific gravity:

		Per cent.
Sucrose		.238
Solids		.028
Available sugar		.262
Glucose	minus	.052

Number of analyses, 2,960.

For changes in specific gravity in successive stages of development, each increase of .001 specific gravity corresponded to the following results:

Specific gravity.	Sucrose.	Solids.	Available sugar.	Glucose.	Number of analyses.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	
1018 to 1029	.066	.016	—.034	.084	146
1029 to 1042	.122	.025	.069	.028	191
1042 to 1052	.290	.011	.062	.017	129
1052 to 1061	.299	.010	.340	—.051	158
1061 to 1071	.273	.023	.305	—.055	137
1071 to 1082	.317	.011	.371	—.065	236

From these it will appear that the sorghum juices, after they have reached a specific gravity of about 1050, increase gradually and with great regularity in saccharine strength and in available sugar until a specific gravity of 1080 to 1082 is attained, and that this increase is fully, upon the average, 0.3 per cent of the weight of the juice for each .001 increase in specific gravity, or an average increase between 1050 and 1082 of 9.6 per cent of the weight of the juice in available sugar.

The practical importance of this fact, which appears to be demonstrated by the very numerous analyses made during the past three years, can hardly be too strongly emphasized.

By reference, then, to the table given on page 493, the farmer may, by simply taking the specific gravity of his sorghum juice, readily estimate the approximate value of the crop for the production of sugar or syrup.

PREPARATION OF SOLUTIONS FOR ANALYSIS OF SORGHUM, MAIZE, AND SUGAR-CANE JUICES.

Fehling's Solution.

Weigh out the following: $C_4H_4KNaO_6.4H_2O$ crystallized Rochelle salt, 2595 grams; powder it and put it in a large glass balloon flask, holding at least 20 liters; add NaHO caustic soda, 820.8 grams, and then pour over it 7 liters of water, and shake up until dissolved.

Dissolve in 3 liters of water 519.6 grams $CuSO_4.5H_2O$ crystallized sulphate of copper, and add the solution of the copper salt to the solution of Rochelle salts and caustic soda; then add water enough to make 15 liters in all.

It is well to powder the Rochelle salts and the sulphate of copper, to hasten the solution of them. It is of advantage to place the hydrate of soda upon the powdered Rochelle salts, in order that its solution may be readily effected, without allowing it to come in contact directly with the glass.

Permanganate Solution.

131.748 grams (132.) of crystallized permanganate of potash, $K_2Mn_2O_8$, dissolved in 30 liters of water, gives a solution of the proper strength.

100 c. c. of decinormal oxalic acid solution should equal 72 c. c. of this permanganate solution.

Basic Acetate of Lead Solution.

4500 grams of pulverized lead acetate, $Pb(C_2H_3O_2)_2$, are mixed with 2700 grams of lead oxide, PbO, and 2500 c. c. of water added to the mixture. It is then boiled for two hours in an iron pot, with stirring, the evaporated water being replaced. Filter in bottles.

Ferric Alum Solution.

Ferric alum, 500 grams; water, H_2O, 5 liters; sulphuric acid, H_2SO_4, 250 c. c. Dissolve the powdered alum in the water, and then add the sulphuric acid.

CHAPTER XVI.

(*a.*) Methods of manufacture of different sorghum sugar, and syrup makers.
(*b.*) Experiments in sorghum sugar manufacture, on a large scale, at the Department of Agriculture, at Washington.
(*c.*) Causes of failure in the manufacture of sugar at the Department of Agriculture, at Washington.

METHODS OF MANUFACTURE.

For the purpose of showing the present methods of manufacture of sugar and syrup, and the variations possible, without endangering success, the following briefly detailed methods are given of a few of those manufacturers who have, thus far, been most successful. It is to be said, that, while the methods differ greatly, they generally agree in the importance of promptness, and in carrying forward the several operations in cleanliness, and especially in the greatest care in defecation of the juices.

It is interesting to see that all of these reports are from the more northerly states, averaging 41° north latitude, and varying from 39° to 44°; also, that the longitude varies from 2° E. to 14° 5′ W., covering an area of 350 by 1,200 miles; thus showing the possible area for the successful cultivation of sorghum for sugar, while the immensely larger area, extending from 39° north latitude to the gulf, and from the Atlantic to the mountain regions of the west, is doubtless better adapted to the growth of this plant than most of the more northern states. Thus far this new industry has been largely limited to the north and west, possibly through greater enterprise in northern farmers and capitalists, and greater readiness to enter upon new industries which give promise of success.

Several of those whose methods are given were among the successful competitors for prizes given by the Department of Agriculture for those who should report the best results in sorghum sugar making in 1882.

Plan for a Cheap, Economical Home Factory.

The following plate, No. XLIX, published by J. A. Field & Co., St. Louis, Mo., presents a plan for a small sugar or syrup works, such as is in very general use among our farmers, and which, at very moderate expense, will enable the farmer to manufacture his small acreage of sorghum into excellent syrup, either for home consumption or for some central factory.

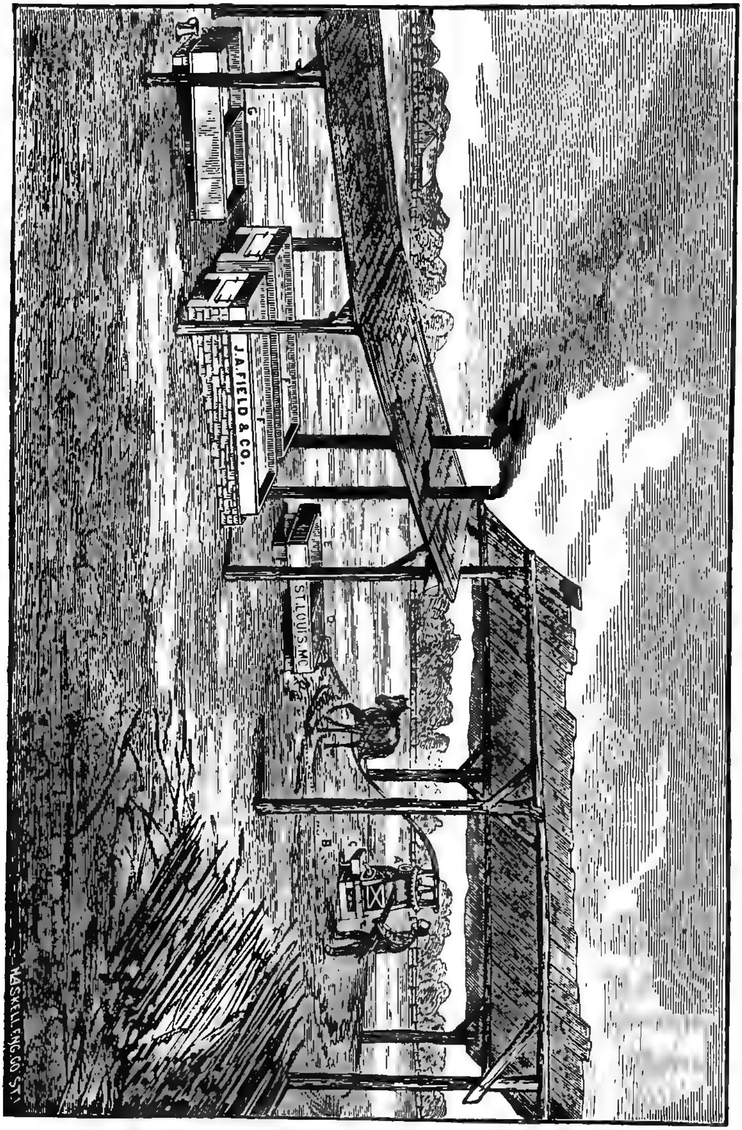


Plate XLIX.

PLAN FOR A CHEAP, ECONOMICAL HOME FACTORY.

A. Location of Mill. *B.* Pipe from Mill to Juice Vat. *C.* Strainer at Mill. *D.* Strainer at Juice Vat. *E.* Juice Vat. *FF.* Evaporators. *G.* Cooling Tank for Syrup.

Champaign Sugar Company, Champaign, Ill.

PROFESSORS WEBER AND SCOVELL.

1. Cane passed through a 3 roll mill, the bagasse saturated with hot water, and then passed through a second 3 roll mill; the juice from both mills received in a common tank.

2. Juice treated with milk of lime in defecators to neutralization, as shown by litmus paper; then heated to boiling and skimmed. After skimming, allowed to settle half an hour or more, and then the clear juice is drawn off from the sediment.

3. Juice from defecator is evaporated in open pan to 25° Beaumé, and the semi-syrup drawn off into settling tanks.

4. After having deposited its impurities, the semi-syrup is drawn off from the sediment and filtered through bone-coal.

5. The semi-syrup from the bone-coal filters is evaporated to melada in vacuum pan; and, after being purged in centrifugal, the molasses is again boiled in vacuum pan to 40° Beaumé for second sugars.

Agricultural Department University of Wisconsin, Madison, Wisconsin.

PROFESSOR SWENSON.

1. Cane pressed as soon as possible after cutting, and the juice strained through a straw filter (bucket filled with straw).

2. Juice heated to lukewarmness and made slightly alkaline with lime, as shown by litmus paper, then heated to boiling as quickly as possible, and steam turned off; then skimmed, and again heated to slight boiling, the steam again turned off, and the fresh scum removed. This operation is repeated two or three times, giving finally a clear juice nearly free from sediment.

3. The defecated juice is evaporated in open pan to about 20° Beaumé,

4. From the evaporator the semi-syrup is taken to vacuum pan, and evaporated to about 42° Beaumé, thence emptied into tin-lined wooden vats, each holding about 50 gallons, where it is allowed to remain three or four days.

Every step hurried as much as possible, averaging about three hours from time cane was pressed till the drawing off from the vacuum pan into the crystallizing tanks.

This process, as will be seen, differs somewhat from the method described by Professor Swenson, and published in the Report of the Committee of the National Academy of Science upon "The Sorghum Sugar Industry," p. 84.

The chief difference is in the method of defecation.

Do not allow the cane to stand stripped in the field.

Work up the cane as soon as possible after being cut.

Defecate the juice as soon as possible after leaving the mill.

For defecation use milk of lime, freed from coarse particles by straining; add it gradually to the juice with vigorous stirring until a piece of red litmus paper is turned to a pale purple.

Heat the juice quickly to the boiling point, as shown by the swelling and breaking of the scum.

Remove the scum after allowing the juice to remain quiet for five minutes.

Draw off the clear juice through an aperture near the bottom of the defecator into the evaporating pan.

And sulphurous acid to the clear juice until a piece of blue litmus paper is reddened.*

Evaporate down until it reaches a density of 45° B., or, if boiled in an open pan, to a boiling temperature of 234° F.

Place in a warm room to crystallize, and in about a week it will be ready to separate.

Sterling Syrup Works, Sterling, Kansas.

1. Juice received in large tanks (500 gallons), divided by a partition, one side being filled with hay, through which the juice is filtered.

2. In the defecator, lime is added to the cold juice till blue litmus shows only a faint tinge of red. Then the juice is heated to 180° F. The steam is turned off, the scum removed, and the juice allowed to settle.

3. After settling, the defecated juice is drawn into the evaporator, heated by steam-pipes, and, with skimming, reduced to 22° Beaumé.

4. The semi-syrup is now exposed to sulphurous acid fumes as it is drawn from the evaporator into tanks, where it remains until sufficiently settled.

5. The semi-syrup is then evaporated in the "finisher," heated by copper coil, to 35° Beaumé, and from the finisher drawn into a cooler 12 feet long and 2 feet wide, in which it is quickly cooled by means of manifold pipe, through which cold water is circulated.

6. After cooling, the syrup is stored in large tanks until all froth has risen to the surface, and is then drawn into barrels.

Nelson Maltby, Geneva, Ohio.

1. Cane crushed in 3 roll mill. Juice passes through a straw filter.

2. Juice heated in the defecator by steam to 180° F., and then

*This step may be omitted if no excess of lime has been added during defecation. It will have no effect on the quantity of sugar obtained, but will make a lighter colored molasses.

neutralized with milk of lime, as shown by litmus paper, after which it is heated to the boiling point; then steam is turned off, scum removed, and, as soon as the sediment settles, the clear juice is drawn by a swing pipe into a tank where it is treated with sulphurous acid until litmus paper is reddened.

3. The defecated juice, after addition of sulphurous acid, is concentrated by a Cook evaporator to about 30° Beaumé, and is then contrated in a pan, heated by steam-pipes, to a boiling point of 228° F. for syrup, and 235° F. for sugar.

The concentrated syrup is stored in room heated to from 80° to 100° F. for from 1 to 6 days, and then purged in a centrifugal.

Drummond Brothers, Warrensburg, Missouri.

1. The expressed juice is filtered through a perforated tin strainer, and received in a tank, in which it is allowed to settle, the juice being drawn from the top into a Cook evaporator, where the only agent for defecation is heat. The scum is removed, and the semi-syrup from this first pan is still further concentrated in another Cook evaporator to 230° F. boiling point, if syrup is intended to be made, or to 234° F. for sugar.

2. From the second Cook pan the syrup (for the purpose of rapid cooling) is passed through a shallow tin trough into the storage tank.

3. For sugar, the syrup is kept in shallow tanks, in a room heated to from 80° to 90° F.

4. The molasses is drained off through sacks.

A. J. Decker, Fond du Lac, Wis.

1. Cane passed through 3 roll mill, and juice filtered through wire gauze and straw filters.

2. Lime is added in the defecators until nearly neutral, the juice remaining slightly acid, and then by steam-pipes is heated as quick as possible to the boiling point, and the steam is turned off. The scum is removed and the sediment allowed to settle. The clear juice is then drawn off by a faucet near the bottom of the defecators. If the defecation is good, the juice should be as clear as water.

3. The juice is evaporated in open pans heated by steam-pipes, and the syrup is drawn into coolers of galvanized iron, with a coil of tin pipe at the bottom, through which is pumped a stream of cold water. From the cooler the syrup is drawn into large storage tanks, and, after crystallizing, the sugar is purged by means of a centrifugal.

Oak Hill Refining Company, Edwardsville, Madison County, Ill.

1. The juice from the mill passes through a long perforated screen for removing mechanical impurities, to the sulphur box, where it is treated with sulphurous acid from the burning of sulphur, the sulphurous acid passing over a water-trough 8 feet long (to take out any sulphuric acid) before it reaches the sulphur box and juice. From the sulphur box the juice is received in tanks, in which some sediment falls.

2. Milk of lime, about 12° Beaumé, is added to the juice in the defecators before heating, and not quite to the point of neutralization, as shown by litmus paper. Heat is now applied by means of steam coils at bottom. When the first heavy blanket of scum is obtained, it is skimmed, and then another scum is brought up and removed. The juice is now boiled briskly for a few minutes, and then allowed to settle. The juice should then be quite clear, and is drawn into settling tanks to permit the further deposit of impurities, and then is drawn into evaporators.

3. The defecated juice is concentrated in a circular evaporator with a scum trough, into which the green scum, which at first forms, is swept as fast as it rises. When all the scum has been removed, the boiling is urged, with high steam (80 pounds) pressure, till a semi-syrup of 20° to 25° Beaumé is obtained.

4. The semi-syrup is then drawn into settling tanks, if not quite clear, and is in a second circular evaporator brought to 35° or 36° Beaumé; but it is desirable to complete the evaporation before the semi-syrup is allowed to cool. The concentrated syrup is cooled as speedily as possible, by allowing it to run over a wide surface exposed to the air before it passes into the storage tanks.

5. Before liming, good results have been obtained by adding to the cold juice in the defecator a small amount of superphosphate of lime.

Jefferson Sugar Company, Jefferson, Ohio.

1. Juice from 3 roll mill, heated by steam-pipes to 180° F., and neutralized with milk of lime; then heated to boiling, skimmed, allowed to settle, and the clear liquor drawn off into a settling tank, where it is made acid with a solution of sulphurous acid or with the gas.

2. Evaporated to semi-syrup with skimming, in open galvanized iron pan, heated by steam, and the semi-syrup finished in a separate pan heated with steam.

William Frazier, Esofea, Vernon county, Wisconsin.

1. Juice received from the mill into settling tanks, and drawn from the sediment into a liming tank, where it is treated with milk or cream of lime to neutralization, as shown by blue litmus paper being turned purple.

2. A long pan, 17 x 3½ feet, divided into compartments of 5, 4, and 8 feet, is used in defecation and evaporation to semi-syrup. The limed juice is drawn into the five foot compartment next the chimney, where it is slowly heated, but never boils, and is skimmed once in five or six hours. From this compartment, which is higher than the rest of the pan, it passes to the four foot compartment, where it is heated nearly to boiling, and is skimmed as necessary, and by a gate the clarified juice passes into the eight foot compartment, which is made like a Cook pan, with divisions 16 inches wide. While passing through this channel of 21 feet, it is rapidly boiled, with the removal of green scum, and then is drawn into a semi-syrup tank, and allowed to settle for about an hour.

3. To the semi-syrup is added a solution of porous alum, about one pint to 100 gallons of semi-syrup. This solution contains one-half ounce of the porous alum to the pint.

4. The semi-syrup is drawn from the sediment into a Cook pan, where it is reduced to syrup. The finished syrup runs through a wooden trough, 32 feet long, to a cooler.

Paul Steck, San Francisco, California.

1. Juice heated to 120 F., and then neutralized with milk of lime, as shown by litmus test, then heating till the scum forms on surface; steam is shut off, and the juice freed from scum and sediment by passing through filter presses, then through filters of bone-black, 3 feet in diameter and 25 feet long.

2. The defecated and filtered juice was evaporated to 21° Beaumé, in double effect apparatus, under 24 inch vacuum.

3. The semi-syrup, if not clear, is again passed through bone-black filters, and then brought to syrup or sugar test in vacuum pan; syrup from vacuum pan run into crystallization tanks, then purged by centrifugals.

William P. Wheeler, Chittenango, New York.

1. Juice flowed from mill through straw filter into the receiving and settling tank, thence into defecator of galvanized iron, where it was heated to 180° F., and by milk of lime just neutralized, as shown by litmus paper; then quickly brought to boiling point; and, before active

boiling began, the heat was withdrawn, the scum removed, and the sediment allowed to subside, which required about half an hour.

2. The clear defecated juice was drawn, by means of a stop-cock placed just above the bottom of the defecator, into a galvanized iron pan, twelve feet long and 4 feet wide, divided into three compartments, connected by gates in the partitions. The skimming was mainly completed in the first and second compartments, and the semi-syrup from the third was allowed to run in a continuous stream into a Cook pan, in which concentration was completed. The syrup was stored in a tin-lined tank until thoroughly cool.

3. The sediment from the defecator was filtered through plaited bag filters, described on page 289, and filtered juice added to the first evaporator.

Rio Grande Sugar Company, Rio Grande, N. J.

1. Juice is expressed by three-roll mill, and the bagasse is again passed through two additional rolls; the juice from both sets of rolls being received in one tank, and thence pumped to another.

2. In this latter there is added to the juice cream of lime, completely saturated with sulphurous acid, which has been passed into it. Enough of this sulphite of lime is added to render juice slightly turbid.

3. After settling, the juice is run into the defecating tanks proper, where it is heated to boiling, then skimmed, and passed through the filter press.

4. The defecated and filtered juice is drawn into the evaporators, where it is reduced by heat from steam coils until scum ceases to rise.

5. The thin syrup is taken into a horizontal vacuum pan, resembling a tubular boiler; where under about 25 inches of vacuum, it is brought to pan liquor, which is brought into the vacuum pan, and concentrated to melada. This, after storing two to five days in a warm room, in iron tanks, passes to the mixer, and next to the centrifugals.

Results Obtained by Different Methods of Evaporation of Sugar-Cane Juice from Louisiana Canes.

The following comparative results, obtained by different methods of evaporation, are given by McCulloh, in his report to the government, and are of interest in this connection.

They were prepared for publication by C. Conrad Johnson, Esq., an experienced sugar-boiler.

In the following table, comparison is made between the several different systems of manufacture, as therein given, both with respect to the amounts of sugars produced, the relative quality or grade of product, and the total pecuniary value in a relative point of view of each

result, the whole being based upon an equal amount of extractable sugar in each case.

VALUE OF A CROP OF CANE MADE INTO SUGAR BY SIX DIFFERENT PROCESSES, INTO HOGSHEADS, WITHOUT BEING SYRUPED, AT THE PRICE EACH CLASS HAS BEEN SOLD OR IS WORTH THIS SEASON, 1847.

[*The whole quantity of dry sugar being in each case 653,367 pounds, and the boiling power required for each crop being 8,000 pounds.*]

Method.	Pounds of first sugar.	Value per lbs. in cents.	Total value of first sugars in dollars.	Pounds of second sugar.	Value per lbs. in cents.	Total value of second sugars in dollars.	Gallons of molasses.	Value per gallons in cents.	Total value of molasses in dollars.	Total value of crop.
1........	433,000	4½	19,485	*43,300	2	866 00	26,734	18	4,812 12	25,163 12
2......	433,000	4½	19,485	153,500	2¾	1,221 25	13,857	18	2,494 26	26,200 51
3	433,000	5	21,650	162,000	3¼	5,265 00	12,874	18	2,317 32	29,232 32
4	433,000	4	17,320	153,500	2½	3,837 50	12,857	18	2,314 26	23.471 76
5	433,000	5½	23,815	162,000	3½	5.670 00	12.871	20	2,574 20	32,059 20
8	440,000	6½	28,600	163,000	4¾	7,742 50	11,949	20	2,389 80	38,732 30
+8......	478,500	6	28,710	141,000	4½	6,345 00	10,041	20	2,008 20	37,063 20

COMPARATIVE EXPENSES, CONSUMPTION OF FUEL, PROFITS, ETC.

	Plantation expense.	Bone-black expense.	Wood burned, cords.	Saving of loss, in dollars.	Net proceeds.	Relative gain, by dollars.	Cost of apparatus.
1........................	$7,000	......	1,515	....	$18,163 12	$13,440 43	$2,000
2........................	7,000	......	1,515	....	19,200 37	12,403 18	2,500
3........................	7,000	......	1,515	....	22,232 32	9,371 23	4,000
4........................	8,000	200	1,948	L. $974 25	14,477 37	17,126 18	12,000
5........................	8,000	200	1,948	L. 974 25	22,885 55	8,718 00	12,000
8........................	8,000	200	550	S.2, 171 75	31,603 55	....	10,000
+8........................	8,000	200	550	S.2, 171 25	31,034 45	569 10	10,000

(In the foregoing table, taken from McCulloh's report, method 1 represents "the old set of kettles;" 2. Set of kettles for syrup, strike high pressure steam pan; 3. Set of kettles for syrup, and strike vacuum pan; 4. Open high pressure steam pans for syrup and strike; 5. The same for syrup, with strike vacuum pan; 8. Rellieux's triple and quadruple effect pan apparatus, clarifiers, and filters; +8. The same, with results obtained from high boiling.)

In the above table, we have the relative values of each of these methods, as far as production, value of the result, and expense attending the same, are concerned, together with the relative cost of each apparatus at the date of the compilation of this table. These results

are alike, both with reference to the total amount of gross values produced and the relative economy of each method, with respect to cost of production, referred to the net product. Thus, in both instances, they stand as follows: 8, +8, 5, 3, 2, 1, 4; the method 8 giving the best and 4 the poorest, proving that the rules indicated by scientific investigation are substantiated by the results of practical experience. From these data we may conclude, therefore, that vacuum apparatus, when properly combined with suitable clarifying appurtenances, will always give the most satisfactory returns, and, in the increased value of the product, will, in a short period, repay the original first cost.

EXPERIMENTS IN SUGAR MANUFACTURE AT THE DEPARTMENT OF AGRICULTURE AT WASHINGTON.

In connection with the laboratory investigations which have been conducted upon the sorghum and maize plants during the past few years at the Department of Agriculture, there have been made, notably, during the seasons of 1880 and 1881, a series of experiments with reference to the production of sugar from these plants upon a scale of commercial importance. A careful record was made of each detail of these several experiments, and, in view of the importance, practically and scientifically, of the results obtained, this record is worthy of very careful study on the part of those contemplating any attempt at sugar making.

This is the more important, since the results of these practical experiments at Washington have been the subject of such ignorant misconception and willful representation, that it is possible the head of the department felt himself justified in his efforts to invest with ridicule and becloud with doubts every effort on the part of those seeking to establish an important industry.

The experiments made at the Department of Agriculture were those of the "small mill" and the "large mill," as they were for convenience designated.

The "small mill" consisted of a "Victor mill," with a capacity of from 40 to 50 gallons of juice per hour, defecator, and evaporator, the latter being an open pan of galvanized iron without partitions. This form was desirable, since each lot of juice defecated was converted into syrup, collected, weighed, and analyzed. Direct heat was used in both defecation and evaporation in the small mill.

The "large mill" consisted of mill, defecators, sulphur box, filters, evaporators, vacuum pan, cars, mixer, and centrifugal. Steam was used throughout in the operations of the large mill.

The crops of sorghum grown for the large mill were as follows:

At Mr. Golden's, about one mile from Uniontown, forty-four varieties of sorghum, in small lots, amounting in all to 13 acres. These varieties were chiefly the same as those grown upon the grounds of the department. There was also grown by him 3 acres of the Liberian and 12 acres of the Honduras. Owing to the excessive drought, thirteen of the small lots failed to germinate, and these were re-planted June 1st and 2nd.

There were also planted upon the grounds of Mr. Carlisle Patterson, just beyond the city limits, some 65 acres of Early Amber and of Link's Hybrid, and, owing to the backward season and ravages of the wire and cut worms, this plat was re-planted three times, the last planting being completed June 18th.

There was also planted upon the grounds of Dr. Dean, about one mile from Benning's Bridge, 12 acres in Honduras, 10 acres in Neeazana, 10 acres in Early Orange, 12 acres in Liberian, and 6 acres in the eight varieties of maize planted upon the department grounds. The sorghums were planted by May 23rd, and the maize by May 25th.

Dr. Dean began re-planting Honduras June 2nd, Early Orange June 7th, Liberian June 9th, Neeazana June 13th. Dr. Dean began second re-planting Honduras June 18th, Early Orange June 20th, Liberian June 21st, Neeazana June 29th.

To any one who has carefully perused this volume, it is useless to say that this delay was fatal to success in the production of sugar, and that failure was inevitable, unless all previous experience was to be falsified.

The failure of the crop to mature, as had been confidently predicted during the summer, was fully realized. At last, with the assurance that frosts would soon render the crop unfit even for syrup, owing to its immature state, it was resolved to begin work, since, with the limited capacity of the mill, it would require at least two months to work up the entire crop of 135 acres. Accordingly, the work of cutting the cane began September 19th, and grinding began September 26th, and was continued without any serious interruption until October 28th. At this time, the cane still remaining on the field, through the effect of frosts and succeeding warm weather, had become worthless. The cane from 93½ acres in all was brought to the mill, the last portions of which had already become sour and offensive.

Those portions worked were of the earliest varieties planted, since there was more hope of possible success with those than with the other varieties.

In the experiments with the large mill, each load of cane was

weighed, the juice measured in the defecator, of which the capacity was known, and at intervals during the day samples of the freshly expressed juices were taken for analysis in the laboratory. The syrups produced were also carefully weighed and also analyzed.

As evidence of the condition of the crop, it may be mentioned that all the seed which had sufficiently matured to make it possible to save, was carefully gathered, and the total product of the 93½ acres was about 150 bushels, or one and two-thirds bushels per acre. If we estimate 17 bushels of seed to the acre as a reasonable crop for land of the character of that selected for growing this sorghum, it will be seen that only 10 per cent of the crop had reached maturity. As this, unfortunately, was intermixed with the other nine-tenths in every condition of immaturity, a large portion not even in blossom, the resulting syrups produced may be anticipated.

On this point, the statements of Peter Lynch, the sugar-boiler, are conclusive, there being, as he says, but two days, October 4th and 5th, when he received cane in even a reasonably matured state, and from this he readily produced sugar. The report of Assistant Parsons, who had immediate charge of the chemical and other work in the mill, will be read with interest as a conclusive statement of the several causes of failure made by an expert of ample experience. See tables A, B, C.

Since this matter is of such vital practical importance, in connection with the production of sugar from sorghum, a brief review of some of the salient points clearly established will be appropriate.

Results from Analyses of Thirty-five Varieties of Sorghum grown in 1881.

By reference to the table, page 198, giving the general results from analyses of thirty-five varieties of sorghum in 1881, it will be seen that the available sugar in their juices during the successive stages was as follows:

AVAILABLE SUGAR.

Stage.	Per cent.
1. Not headed out	— 3.82
2.	— 4.45
3. Fully headed out	— 3 92
4.	— 4 29
5. In full blossom	— 3.81
6.	— 2 87
7. Seed in milk	— 1 98
8.	— .64
9. Seed in dough	+ 1 14
10.	+ 2 86
11. Seed hard	+ 4 14
12.	+ 6.34
13.	+ 7 61
14.	+ 8 87
15.	+ 9 24
16.	+11.14
17.	+11.02
18.	+11.77
19.	+ 9.83
20.	+ 6.79

Now, a large portion of the crop was not yet in blossom, *i. e.*, was at about the fourth stage, while not over a tenth had matured the seed, *i. e.*, reached the eleventh stage. If we take an average of the fifth to the eleventh stages, inclusive, we shall find that, while the ninth, tenth, and eleventh stages give a total of 8.14 per cent plus, the fifth, sixth, seventh, and eighth stages give a total of 17.51 per cent minus available sugar, or an average for the seven stages of —1.17 per cent. By this is meant that the per cent of sucrose was 1.17 less than the sum of the per cents of glucose and solids in the juices. It will follow, then, that the average condition of the crop was such as to absolutely forbid the hope of any sugar being produced, and that its production, at any period during the working, was only possible when a lot of cane might happen to be brought in which was considerably better than the average, as indeed occurred two or three times during the month of grinding.

The following tables represent the results of the work, and it will be seen that these results are in entire harmony with the preceding statements:

TABLE A.—CANES CRUSHED.

Received from—	Tons.	Pounds.
Patterson Farm	104	80
S. M. Golden	[illegible]	1,304
Dr. Dean	25	1,060
Total	228	2,444

TABLE B.—JUICES EVAPORATED AT SUGAR MILL, DEPARTMENT OF AGRICULTURE.

Date.	Specific gravity.	Gallons after defecation.	Per cent of glucose.	Per cent of sucrose.	Per cent of other solids.	Per cent of sucrose by polariscope.	Per cent + available sucrose.	Per cent — available sucrose.	Juice.	Glucose.	Sucrose.	Solids.	Sucrose by polariscope.	Available sucrose.	Available sucrose.
1881.									Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	+Lbs.	—Lbs.
Sept. 27	1.057	1,663 2	3.86	9.39	1 74	8 62	3 79		11,080.7	543 51	1,322 18	245 00	1,213 76	533.67	
28	1.066	1,771.2	9 66	6 30	2 99	4 71	None.	6 35	14,984 4	1,447 49	1,254 02	548 03	705.66		741.50
28	1 063		9 99	4 46	2.24	2 01	None.	7.77							
29	1 061	1,479 6	5 24	9 69	.85	8 78	3 60		12,517 4	655 91	1,212 94	106.39	1.099.03		106.39
29	1.062		9 00	5 52	2.05	4 08	None.	5 53							
30	1.065	1,738.8	12.20	3 45	2 66	3 25	None.	11 41	14,700.2	1,793.42	507.16	391.03	477.76		1,677 29
30	1.059		5.84	8 70	2.22	8 91	0 64								
Oct. 1	1.069	1,123 2	10 43	5 88	2 39	5 40	None.	6 94	9,502 3	991.09	558 74	227.10	513.12		659 45
3	1 075	831 6	11 74	5 63	2.90	2 69	None.	9 01	7,035 3	825.94	396.09	204.02	189 25		633 87
3	1 068		3 62	11 56	3 17	12 21	4 77								
4	1 070	1,055.6	5 85	9 79	1 08	10 53	2 86		9,776.4	971.92	957.11	105.59	1,029.45	279.60	
4	1 063		2 78	11 75	1 08	11 54	7 89								
4	1 063		3 50	11 08	1 31	11.14	6 27								
5	1 074	550 8	3.84	13 44	.55	12 55	9 05		4,659 8	178.94	626 28	25.63	584 80	421 71	
6	1.070	723.6	5 72	9 98	1 82	10 01	2 44		6,121 7	350.16	610 95	111.42	612.78	149.37	
6	1.055		7 39	5 04	1 83	3 64	None.	4.18							
6	1 066		5 80	9 02	1.83	8 13	1 39								
10	1.043	1,522.8	5 23	5 28	99	3 53	None.	.94	12,882 9	673.77	680 21	127.54	454 76		121 10
10	1.068		8.19	6 67	1 85	5 76	None.	3.37							
11	1.060	1,944.0	3 89	9 85	1 59	8 25	4 37		16,446.2	639.75	1,619 95	261.49	1,356 81	718 71	
11	1 051		4.94	7 81	1 47	6 49	2.30								
12	1.053	1,933.2	4 68	7.15	1 46	6 54	1.01		16,354 9	765 40	1,169.37	238.78	1,076 15	165.19	
12	1.044		4.19	6.82	.38	5 23	2.25								
13	1.057	1,976 4	4.37	8 31	1 46	7 85	2.48		16,721 7	730 73	1,389.57	241.13	1,312 65	417 71	
13	1.052		4 51	7.45	1 30	6.23	1.64								
14	1.055	756.0	4 85	7 87	Lost.	6 28			6,395 8	310.19	503.34	*121.52	401 65	71 63	
14	1.060		4.49	8 73	Lost.	7 83									
15	1.058	1,512.0	1.35	10.75	3 49	7.85	5.91		12,791.5	182.68	1,375.08	446.42	1,004.13	745.98	

*The solids were estimated at the average from the other juices. Per cent of sucrose by polariscope of that by analysis, 78.16.

TABLE B.—JUICES EVAPORATED AT SUGAR MILL, DEPARTMENT OF AGRICULTURE—*Continued.*

Date.	Specific gravity.	Gallons after defecation.	Per cent of glucose.	Per cent of sucrose.	Per cent of other solids.	Per cent of sucrose by polariscope.	Per cent + available sucrose.	Per cent — available sucrose.	Juice.	Glucose.	Sucrose.	Solids.	Sucrose by polariscope.	Available sucrose.	Available sucrose.
1881.									*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*+Lbs.*	*—Lbs.*
Oct. 15	1.071	....	3 93	10 68	4 15	10.06	2 60	....	....	....	....	....	....	....	....
15	1 067	....	4 74	11 19	2 43	9 85	4 02	....	....	....	....	....	....	....	....
17	1 074	723.6	7 14	8 91	2 94	7.84	None.	1 17	6,121 7	437.09	545.44	179.98	479.94	....	71.63
17	1.069	....	11 63	3 40	3 11	0 78	None.	11 34	....	....	....	....	....	....	....
19	1 029	1,846 8	5 79	1 08	1 09	—	None.	5 80	15,633 9	905 20	168 85	170 41	....	....	906.76
19	1 031	....	6 24	0 55	1 64	—	None.	7 33	....	....	....	....	....	....	....
19	1 029	....	6 09	0 71	1 36	—	None.	6.71	....	....	....	....	....	....	....
20	1 084	993.6	14 35	4.11	1 69	1 16	None.	11 93	8,405 9	1,206.25	345.48	142.06	97.51	....	1,002.83
20	1 045	....	8 19	2 40	1 13	1 82	None.	6 92	....	....	....	....	....	....	....
20	1.055	....	8 17	4 16	1 59	3.69	None.	5 60	....	....	....	....	....	....	....
20	1.024	....	5.00	0 64	2 12	—	None.	6 48	....	....	....	....	....	....	....
22	1.052	1,544 4	7 12	5 03	1 60	4.08	None.	3 69	13,065.6	930 27	657 20	209.05	533 08	....	482.12
22	1 055	....	6 65	6 05	2 41	5 91	None.	3 01	....	....	....	....	....	....	....
26	1 057	1,004 4	6 79	5 32	3.02	6 13	None.	4.49	8,497 2	576 96	452 05	256.52	520.88	....	381.43
Av'age	1 058	1,339.74	6 383	6 943	1 899	6 614	3 643	6 190	....	....	....	....	....	....	....
Total	....	26,794 8	268 08	291.60	75 98	251 36	69.28	130.00	226,295.5	14,716 67	16,242 01	4,359.11	12,563.17	3,503.57	6,835.37

TABLE C.—SYRUPS MADE AT SUGAR MILL, DEPARTMENT OF AGRICULTURE.

Date. 1881.	Specific gravity.	Gallons, 231 cubic inches.	Weight, lbs.	Per cent of glucose.	Per cent of sucrose.	Per cent of other solids.	Per ct. of sucrose by polariscope.	Per ct of available sucrose. *	Glucose. Lbs.	Sucrose. Lbs.	Solids. Lbs.	Sucrose by polariscope. Lbs.	Avail'ble sugar. +Lbs.	Avail'ble sugar. —Lbs.
Sept. 27.....	1.453	7.50	90.89	23 50	50.92	8.98	29 24	18 44	21 36	46 28	8.16	26 58	16.76	....
27.. ..	1.429	120 00	1,430.14	31.60	41.04	11 36	38 23	— 1 92	451.92	586 93	162 46	547 00		27.45
29.. ..	1.430	123 75	1,475 87	32.75	37 34	14 71	31 27	—10 12	483 35	551 00	217 00	462 00	....	149.35
30.....	1.392	120 00	1,393 11	42 25	30.69	18 05	30 62	—29 61	588 59	428 00	251 00	427.00	....	411.59
30.. ..	1 426	127.50	1,516 34	41 50	32 78	12 32	29 40	—21 04	629 28	497 00	187 00	446 00	....	319.28
Oct. 1......	1 492	116 25	1,446 53	38.10	38 38	10 52	28 76	—10.24	551 13	555 18	152 17	416.00	....	148 12
1.... .	1 420	112 50	1,332 32	40.00	31.07	14 93	26 65	—23 86	532 93	414 00	199 00	355 00	....	317 93
3.. ..	1 426	123.75	1,471.74	38.50	33 25	*15 25	30 21	—20 50	566 62	489 00	224 00	445.00	.. ....	301.62
3.....	1 426	18 75	222 99	38 50	33.25	15 25	30 21	—20 50	85.85	74 14	34 01	67 37		45.72
4.....	1.420	101.25	1,199 08	37.50	32.78	7.52	30 38	—12 24	449.66	393 06	90.17	364.28	.. ....	146.77
5.....	1 413	135.00	1,500.90	17.65	53 35	9.60	53.62	25 10	280.79	848.75	152.73	853 04	415.23	....
6.....	1.405	71.25	834.89	15 50	52.63	9 67	54 76	27 46	129.41	439 40	80 73	449 19	229.26	....
8.....	1 404	90 00	1,053 84	23 65	44.56	8.59	41 31	12.32	249.23	469.59	90.52	435.34	129.84	....
11.....	1.414	146.25	1,724.69	27 00	47 60	6.00	37 91	14 60	465.67	820 95	103 48	653 83	251 80	. ...
11......	1.430	120 00	1,431.14	29 25	42.75	8 08	38 81	5 50	418.61	611 81	114.49	555.43	78 71	....
12.....	1.427	105 00	1,249.62	27.90	41.42	9 48	38 56	4 04	348.64	517.59	118 46	481 85	50.49	....
13.....	1 423	112 50	1,335 13	28.00	41 80	13 20	38 56	.60	373 84	558.08	176.24	514 83	8 00	....
14.....	1 398	138 75	1,615 23	25 65	41 23	12.92	37.83	2 66	414 31	665 96	208 69	611 04	42 96	....
14.....	1 397	90.00	1,048 59	25 00	41 04	14 96	37.34	1 08	262 15	430 34	156 87	391 54	11.32	....
17.....	1.382	93.75	1,055.53	21.80	43 61	10.19	40 33	11 62	230.11	460 23	107 56	425 70	122.56	....
17......	1.382	127.50	1,469 55	21 80	43 61	10 19	40 33	11 62	820.36	640.87	149 75	592 67	170.76	....
18.....	1.391	93 75	1,087.60	36.65	26.98	13 37	23 24	—23 04	398 61	293 43	145 41	252.76	. .....	250.59
19.. ..	1.388	116.25	1,345.70	18 00	47 03	7 97	47 95	21 06	242.23	632 88	107 25	545.26	283 40	... .
19.. ..	1.388	56.25	651.15	18 00	47.03	7 97	47 95	21 06	117.21	306 24	52 10	322 32	136.93	....
20......	1 395	123 75	1,439 74	51 50	14.73	9 17	21 87	—45 94	741.47	212 07	132 02	314 82	....	661.42
21.... .	1 385	3 75	43.32	39.35	26 32	14 53	22 84	—27 56	17 05	11 40	6 29	9.89	.. ..	11 94
21......	1 385	146 25	1,689 32	39.35	26 32	14.53	22 84	—27 56	664.75	444 63	245.46	385.84	....	465.58
24.....	1 389	131 25	1,520.43	33 25	36.39	9 36	32 40	— 6.22	505.54	553.28	142.30	492.62	....	94 58
28.....	1.399	105.00	1,225.10	36 15	36 39	....	32 08	. ..	442 87	445 81	. . ..	393 01	2.94	.. ..
Average..	1 411	.. ...	....	31.02	38.49	11 38	35.02	— 3.68						
Total....	......	2,977.50	34,990.48	....	....	. .....	....	....	10,983.54	13,397.90	3,815 15	12,337.22	1,957.96	3,351.92

Average weight per gallon ....pounds.. 11 75
Average specific gravity 1.411
Average gallons juice for one gallon syrup............................ 9 00
Average per cent syrup from juice...................................... 11.08
Average specific gravity of juice. 1 058
Average available juice from stalks.......................per cent.. 51 60
Average pounds stripped stalks for one gallon syrup...................154.0

Per cent of total sucrose in juices recovered in syrups 82.49
Per cent of total glucose in juices recovered in syrups..................74 64
Per cent of total solids in juices recovered in syrups.....................87.53
Per cent of total sugars in juices recovered in syrups.....................78.75
Per cent of sucrose by polariscope of that by analysis.....................92.07

* Obtained by subtracting the sums of "glucose" and "other solids" in juice from the percentage of sucrose.

Of the juices analyzed, nineteen gave an average per cent of available sugar of 3.643 plus, while twenty-one gave an average per cent of 6.190 minus, or a total average of the forty equal to 1.518 minus.

Also, of the syrups analyzed, fourteen gave an average per cent of available sugar of 12.65 plus, while fourteen gave an average per cent of 20.03 minus, or a total average of the twenty-eight equal to 3.68 minus.

It will be observed also that, of the several lots of juice worked, nine gave an aggregate of 3,504 pounds of available sugar, while eleven lots gave an aggregate minus amount of 6,835 pounds; or, in other words, had these juices been all mixed in one lot, and had there been added 3,331 pounds of sugar, it would have been practically impossible to have recovered a pound of that added or of that present originally in the juice.

The table of syrups shows that, of the twenty-nine analyzed, fifteen gave an aggregate of 1,958 pounds of available sugar, while the remaining fourteen gave an aggregate of 3,152 pounds minus of available sugar; or, in other words, had these twenty-nine syrups been thrown together in one lot, and 1,194 pounds of pure sugar added, it would have been impossible to have recovered from this mixture a pound of the sugar added or originally present in the syrup.

It will also be observed that during the process of manufacture there was lost 17.5 per cent of the sucrose in the juice, 25.4 per cent of the glucose, and 12.5 per cent of the solids.

It is noticeable that the loss of glucose was considerably greater than that of sucrose, and this may be due to the action of lime, which effects the destruction of glucose, as has been long known to be the case. It is probable that this decrease in the relative amount of glucose accounts for the fact that the average determinations with the polariscope are more nearly those of analysis in the syrups than in the juices, they being only 8 per cent less than the analysis in the case of the syrups, while they are nearly 22 per cent less than the results of analysis in the case of the juices.

The character of the canes worked, may also be seen by the low specific gravity averaging 1.058 and the low percentage of syrup which the juice yielded upon evaporation (11), for, as will be seen by reference to the work of the small mill, the average of twelve lots of juice from canes grown upon the department ground gives 21 per cent of syrup of a greater density, in the juice, or nearly double the amount of that obtained above. The above specific gravity, is that of juice from canes which have not attained their best condition, since, as the analyt-

ical results show, the maximum content of both syrup and sugar was found when the average specific gravity of the juices was 1.082.

Experiments with the Small Mill.

Near the close of the season, when some varieties had already begun to fall off in their content of sugar, and other varieties were still improving in quality, the crop of thirty-five varieties of sorghum, grown on the grounds of the Department of Agriculture was cut, leaving enough of each variety standing in order to continue and complete the daily analyses going on in the laboratory.

The several lots were in succession cut, weighed, and the juice obtained from each lot, and a sample analyzed.

The juice was defecated with milk of lime, as usual, and the defecated juice evaporated in an open pan to a syrup sufficiently dense to be kept without danger of fermentation. The syrup was weighed and also analyzed.

The object of these experiments was to determine whether it was not possible to prepare, with simple and inexpensive apparatus, such as the ordinary farmer might possess, syrups of high grade, *i. e.*, containing a large per centage of sugar. These syrups, it was intended to further reduce and crystallize in the vacuum pan of the large mill, and thus show the farmer that he could, with little expense, prepare syrups from which sugar could be profitably extracted; and also convince refiners and others that they could safely purchase these syrups and as readily obtain from them the sugar as from similar products from the sugar-cane.

The experiments made at the Department of Agriculture in 1878 and 1879 had sufficiently demonstrated the ease with which crystallizable sugar could be obtained even with this simple outfit, but the practical difficulty experienced in purging it without a centrifugal machine was such as to warrant us in recommending the farmer not to endeavor to make sugar, but to make these high grade syrups. He then could secure a local market for consumption as syrups, or, should the product be very great, the refiners would become purchasers so soon as convinced that they could safely and profitably work these syrups for sugar.

As evidence that our work in previous years sufficed to warrant our discontinuing experiments in that direction, those results are here given, from which it will be seen that we then obtained an amount of sugar fairly comparable with the average results from sugar-cane. In 1878, we obtained the syrups from the juices of sorghum, maize, and pearl millet of very excellent quality in their content of sugar, and

we obtained from these syrups, sugars of a high grade when compared with other muscovado sugars as these were. The sorghum sugar polarized 94°, the maize sugar polarized 90°, and the sugar from pearl millet 92°.

The yield of the syrup in sugar was large, the sorghum syrup giving in its first crystallization 34.6 per cent of its weight in sugar, another sample 31.3 per cent; the maize syrup giving in sugar 32 per cent of its weight.

In 1879, we obtained syrups from sorghum, which in their first crystallization yielded 54.7 per cent of their weight in sugar of excellent quality; another syrup gave 47.5 per cent, while a syrup from the stalks of common field corn gave 39.3 per cent of sugar.

The above results fully justified the conclusion given in the report of the work of 1878, at the Department of Agriculture, viz.:

> The point which these experiments have fully settled is, that there exists no difficulty in making, from either corn or sorghum, a first rate quality of sugar, which will compare favorably with the best product from sugar-cane grown in the most favorable localities.

During the past years, nothing has been done or been developed by later investigations to necessitate any modification of the above conclusion. Since then, efforts have been directed toward the determination of those conditions which would render such production the most profitable, and the continued and careful study of these several plants during their period of life has appeared most likely to throw light upon practical work.

Besides the experimental plat of sorghum upon the department grounds, there were grown, as has been stated, numerous small plats of these several varieties upon the farm of Mr. Golden, near Uniontown; also small plats of several kinds of maize upon the farm of Dr. Dean, near Benning's Station; also a small plat of six varieties of sorghum by Mr. Green upon the Potomac flats at the Virginia end of the Long Bridge. These small plats were intended to be worked at the small mill, for the purpose of learning their relative productiveness and value in the production of good syrups, rich in sugar.

The number of separate experiments made with the small mill was 40, and these extended from September 12th to October 22nd.

The following tables give every detail concerning these experiments, and will repay a very careful consideration. Analyses of juices and syrups, weights of stalk and average yield, percentages of juice and of syrups, the time occupied in each operation, temperatures of defecation, and in fact any detail calculated to throw light upon these results is given.

In reference to these results, which have proved in many respects so surprising, many may see abundant reason for any failure which has attended their efforts, and will be impressed with the importance of establishing by careful experiment, points which by many would be readily assumed as true, and even with a show of reason, but which in fact may be far different from their preconceived ideas.

EXPERIMENTS WITH SMALL MILL.

No. of experiment.	Variety.	Date of working.	Where grown.	Stripped weight, pounds.	Feet in row.	Suckered or not.	Juice, pounds.	Per cent of juice to stripped stalk.	Specific gravity of juice.	Polarization of juice.	Per cent of sucrose in juice.	Per cent of glucose in juice.	Per cent of solids in juice.	Stripped stalk per acre, pounds.	Per cent sucrose in juice available.
1	Egyptian Sugar Corn, ears plucked.	Sept. 12.	Department of Agriculture.	16	..	Yes	6	37.5	1.058	Lost.	9.54	2.89	2.50	....	4.15
	Egyptian Sugar Corn, ears unplucked	Sept. 12	...do..	65	.	Yes.	20.5	31.5	1.056	Lost.	10.41	2.78	1.15	6,729	6.48
	Lindsay's Horse Tooth	Sept. 12	...do	67	240	Yes.	30	44.8	1.053	8.42	8.98	2.40	3.00	5,772	3.58
	Blount's Prolific	Sept. 12	...do	17	240	Yes.	6	33.3	...	Lost.			...	2,293	.....
	Improved Prolific Bread	Sept. 12	..do	204	240	Yes.	81.5	40.0	1.048	Lost.	7.86	1.99	2.60	12,750	3.27
	Broad White Flat Dent	Sept. 12	.. do	290	240	Yes.	115.5	39.8	1.051	Lost.	7.79	2.49	2.46	16,744	2.84
	Long Narrow White Dent	Sept. 12	...do	279	240	Yes.	123.5	41.3	1.055	8.00	9.48	2.01	1.59	16,146	5.88
	Chester County Mammoth	Sept. 12	...do	94	240	Yes	35.5	37.8	1.061	Lost	10.90	1.64	2.96	6,557	6.30
	18-rowed Yellow Dent	Sept. 12	...do	158	240	Yes	61.5	38.9	1.056	8.76	8.28	2.42	2.79	9,838	3.07
2	Early Amber. Row 1	Sept. 13	...do	341	200	Not.	148	43.4	1.088	Lost.	15.56	2.52	.99	24,757	12.05
	Early Golden. Row 2	Sept. 13	.. do	477.5	200	Not.	221	46.3	1.085	16.39	16.52	2.07	1.69	34,667	12.76
	White Liberian Row 3.	Sept. 13	. do	364	200	Not	177	48.6	1.080	15.68	14.62	1.62	4.45	26,426	9.61
	White Liberian Row 4.	Sept. 13	..do	406.5	200	Not	206	50.7	1.079	15.10	13.60	1.67	4.55	29,512	7.38
3.	Black Top Row 5.	Sept. 14.	...do	648	280	Not	217		1.070	9.76	9.76	3.50	6.17	33,603	.09
	African Row 6.	Sept. 14	.. do	378	260	Not.	198.5	52.5	1.067	10.29	10.41	2.87	5.32	21,110	2.22
	Regular Sorgho Row 9	Sept. 14	...do	416	285	Not.	212	51	1.056	7.09	7.33	3.59	4.79	21,194	— 1.05
4.	Miller's Sugar Cane No. 26.	Sept. 15	Golden	1,292	..	Yes	594.5	46.0	1.052	5.58	- 7.47	4.96	3.16	...	— .65
5.	Wallis' Hybrid No. 27.	Sept. 15	do	764	...	Yes.	380.5	49.8	1.062	6.67	8.45	5.82	3.62	....	— .99
6	Bear Tail No. 14	Sept. 15	do	1,628	...	Yes	770.5	47.3	1.051	4.49	6.50	5.88	3.60	....	— 2.98
7.	Bear Tail No. 14.	Sept. 16	.. do	264	..	Yes.	130	49.2	1.051	Lost.	6.50	5.88	3.60	.....	— 2.98
	Iowa Red Top No. 15	Sept. 16	do..	1,170		Yes.	582.5	49.8	1.058	4.81	6.91	6.91	2.24	....	— 2.24
8.	Oomseeana Row 8.	Sept. 16.	Department of Agriculture.	342	267	Not.	174	50.9	1.069	8.54	10.06	4.73	3.49	13,599	1.84
	White Mammoth Row 7.	Sept. 16	...do..	509	270	Not	251	49.3	1.074	10.86	11.76	3.79	4.46	27,373	3.51
9.	Link's Hybrid Row 10.	Sept. 17	...do..	558	280	Not	285.5	51.1	1.067	11.39	12.08	1.86	2.64	28,936	7.58
	Link's Hybrid Row 11.	Sept. 17	...do..	583	285	Not	307	52.7	1.062	12.20	13.06	1.33	2.63	29,702	9.10
10.	Sugar Cane Row 12.	Sept. 17.	.. do..	592	285	Not	314	53	1.066	11.28	11.91	1.46	2.78	30,161	7.70
	Goose Neck Row 13.	Sept. 17.	...do..	433.5	285	Not.	243.5	56.2	1.050	5.45	6.35	4.07	2.29	22,086	— .01

EXPERIMENTS WITH SMALL MILL—*Continued.*

No. of experiment.	Variety.	Date of working.	Where grown.	Stripped weight, pounds.	Feet in row.	Suckered or not.	Juice, pounds.	Per cent of juice to stripped stalk.	Specific gravity of juice.	Polarization of juice.	Per cent of sucrose in juice.	Per cent of glucose in juice.	Per cent of solids in juice.	Stripped stalk, per acre, pounds.	Per cent sucrose in juice available.
11.	Bear Tail .... Row 14.	Sept. 19.	Department of Agriculture.	486	285	Not.	237	48.8	1.065	10.08	10.92	2.41	5.35	21,252	3.16
	Iowa Red Top .... Row 15.	Sept. 19	.. do..	429	285	Not	214	49.9	1.075	Lost.	14.63	1.45	7.21	21,856	5.97
12	Egyptian Sugar Corn	Sept. 20	Dr. Dean	1,600		Yes	646	40.4	1.055	8.40	8.29	3.65	5.65	......	— 1.01
13	New Variety .... Row 16.	Sept. 27.	Department of Agriculture.	575	285	Not	262.5	45.7	1.068	Lost.	12.67	1.90	2.75	29,294	8.02
	Early Orange .... Row 17.	Sept. 27.	.. do..	381	178	Not	168	44.1	1.065	10.04	10.57	3.69	2.12	31,079	4.76
	Early Orange .... Row 18.	Sept. 27.	... do..	253	154	Not.	100.5	39.8	1.064	9.80	13.57	3.38	— .45	23,584	10.19
	Orange Cane .... Row 19.	Sept. 27.	.. do..	327	174	Not	139.5	42.7	1.067	10.50	10.95	3.35	2.42	30,831	5.18
	Neeazana .... Row 20.	Sept. 27	... do..	314.5	174	Not	130	41.3	1.063	9.39	9.94	3.80	2.72	26,244	3.42
14.	Early Amber .... No. 1.	Sept. 27	Golden	985		Yes	423.5	44.2	1.063	.07	3.75	10.85	2.80	......	— 9.90
	Early Golden .... No. 2.	Sept. 27.	.. do..	640		Yes.	289	45.1	1.069	.00	3.66	11.69	3.07	......	—10.10
15.	White Liberian .... No. 3.	Sept 28.	.. do..	1,220	...	Yes	495.5	40.6	1.070	.00	2.30	13.25	2.48	......	—13.43
	New Variety .... No. 16.	Sept 28.	... do..	775	...	Yes	254	45.7	1.057	4.98	5.74	7.56	2.02	......	— 3.84
16	White Liberian .... No. 4.	Sept. 28.	.. do..	3,840	..	Yes	1,137.5	45.2		6.64		...	....	......	......
17.	Wolf Tail .... Row 21.	Sept. 29.	Department of Agriculture.	390	168	Not	172.5	44.2	1.068	11.56	11.67	1.87	3.54	33,707	6.26
	Gray Top .... Row 22	Sept. 29	do..	490	230	Not	218.5	44.6	1.052	7.31	?.56	3.08	9.90	30,934	—12.42
	Liberian .... Row 23.	Sept. 29	do..	560	280	Not.	250	44.6	1.059	8.34	8.18	4.24	3.16	29,040	.78
18	Honduras .... No. 42.	Sept. 30	Golden	1,105		Yes	366	33.1	1.048	Lost.	1.92	10.07	2.15	......	—10.30
	Neeazana .... No. 50.	Sept. 30.	.. do..	1,085		Yes	518.5	47.8	1.058	Lost.	8.84	4.72	2.27	......	1.85
	Liberian .... No. 51.	Sept. 30.	. do..	930		Yes	421	45.3	1.066	5.79	6.34	9.14	3.28	......	— 6.08
19	Mastodon .... Row 24.	Sept. 30.	Department of Agriculture.	598	290	Not	307	51.3	1.051	8.15	8.24	3.09	4.22	29,941	.93
	Honduras .... Row 25.	Sept. 30	.. do..	688	290	Not	375	54.5	1.062	9.24	8.47	5.06	3.74	34,447	— .33
20	Oomseeana .... No. 8.	Oct. 1	Golden	2,222		Yes	1,045.5	47.1	1.055	2.76	6.30	6.57	2.24	......	— 2.51
21.	Liberian .... No. 51.	Oct. 3	... do..	750		Yes.	316.5	42.2	1.072	1.04	5.16	10.78	2.53	......	—12.15
	Oomseeana .... No. 8.	Oct. 3	... do..	494		Yes	211	42.7	1.059	1.05	2.62	10.45	2.41	......	—10.24
	Regular Sorgho .... No. 9.	Oct. 3	... do..	1,260	..	Yes	606	48.1	1.060	2.44	3.80	9.67	2.70	......	— 8.57
22	Oomseeana .... No. 8.	Oct. 3	... do..	2,620	...	Yes	1,085	41.4	1.057	2.68	3.32	8.92	3.46	......	— 9.06

EXPERIMENTS WITH SMALL MILL—*Continued.*

No. of experiment.	Variety.		Date of working.	Where grown.	Stripped weight, pounds.	Feet in row.	Suckered or not.	Juice, pounds.	Per cent of juice to stripped stalk.	Specific gravity of juice.	Polarization of juice.	Per cent of sucrose in juice.	Per cent of glucose in juice.	Per cent of solids in juice.	Stripped stalk per acre, pounds.	Per cent sucrose in juice available.
23.	Goose Neck	No. 13.	Oct. 4.	Golden..	2,416	...	Yes.	1,162.5	48 1	1 065	7 36	7.26	7 10	1 19	...	— 1.03
24.	Regular Sorgho	No. 9.	Oct. 4	.. do..	2,300	..	Yes.	1,055	45 9	1 067	.70	2 67	11.94	1.51	...	—10.78
25.	Goose Neck	No. 13.	Oct. 5	.. do..	474	...	Yes.	222.5	46.9	1.067	5 38	7 12	8.31	1 11	...	— 2.30
	Black Top	No. 5.	Oct. 5	....do..	2,042	...	Yes.	729	35 7	1.063	6 25	6 99	6 87	1 61	...	— 1.49
26	African	No. 6.	Oct. 5	. do..	1,524	.	Yes.	746	49	1.059	6 09	6 95	6 01	1 59	...	— .65
27.	Sugar Cane.	Row 26.	Oct. 6	Department of Agriculture.	393	290	Not.	202	51 4	1 053	Lost.	6 15	3 49	3 27	19,677	— .61
	Wallis Hybrid	Row 27.	Oct. 6	.. do..	520	290	Not	291 5	56 1	1 053	Lost.	5 68	4 27	2 96	26,036	— 1 55
	White Imphee	Row 28.	Oct. 6	.. do..	370	290	Not	202	54.6	1 041	4 94	5.45	1 62	3 01	18,525	.82
	Goose Neck	Row 29.	Oct. 6.	... do..	362	290	Not	202	55 8	1 044	3 62	3 98	3.35	3.30	18,125	— 2.67
	White African	Row 30.	Oct. 6	...do..	480.5	290	Not	249.5	51.9	1 070	Lost.	11.38	1 34	3 82	24,058	6.22
28.	West India	Row 31.	Oct. 7	...do..	471	290	Not.	247	52.4	1.072	9 89	11 03	4 37	1 85	23,582	4 81
	Sugar Cane	Row 32.	Oct. 7	...do..	254	290	Not.	127	50	1 055	7.10	7 58	3.63	2.06	12,717	1 89
	New Variety, Barger	Row 33.	Oct. 7	...do..	341 5	290	Not	170 5	49 9	1.070	11.03	11.26	3 75	1 99	17,099	5.52
	Minnesota Early Amber	Row 34.	Oct. 7	...do..	397	290	Not	207	52.1	1 077	13 39	13.96	1 91	2.56	19,877	9.49
	Holcus Saccharatus	Row 35.	Oct. 7	...do..	271	290	Not.	107 5	39 7	1 049	Lost.	5 27	2 32	3 89	14,220	— .94
	Honey Cane	Row 38.	Oct. 7	... do..	759	290	Not	449	59.2	1 067	10 70	11 88	3.42	1 75	39,239	6.71
29.	Minnesota Early Amber	Row 34.	Oct. 7	...do..	105	117	Yes	48 5	46 2	1 078	14 24	14.82	1 56	3 33	16,977	9.93
	New Variety	Row 33.	Oct. 7	...do..	91	119	Yes.	34.5	37.9	1 082	14 17	14 70	1 84	3 33	13,800	9.53
	Sugar Cane	Row 32.	Oct. 7	...do..	114	120	Yes	60 5	53 1	1 070	12.17	12 27	2 86	2.86	16,128	6 55
	West India	Row 31.	Oct. 7.	...do..	177	121	Yes	83.5	47 2	1 069	14 94	15 57	1 95	3.66	24,418	9.96
	Holcus Cernus, White	Row 37.	Oct. 7	...do..	237 5	290	Not.	66	27 8	1 078	Lost.	13 96	1 35	? 2 91	13,313	9.70
	Early Amber.	Row 1.	Oct. 7	... do..	173	140	Yes.	78 5	45 4	1 087	Lost.	16 06	1.38	3 81	21,074	10.87
	Early Golden	Row 2.	Oct. 7	...do..	188.5	140	Yes.	91	48 3	1 088	15.45	15 93	1.37	3 93	23,201	10 63
	White Liberian	Row 3.	Oct. 7	...do..	126.5	138	Yes.	54.5	43.1	1 083	14.68	16 03	1 37	3 46	17,006	11 20
	White Liberian	Row 4.	Oct. 7	...do..	118	140	Yes.	56	47 5	1 098	Lost.	15 81	1 27	4 27	15,329	10 27
	Black Top	Row 5.	Oct. 7	do..	196	140	Yes	99	50 5	1 074	12 35	13.10	1 22	3 78	22,848	8 10
	African	Row 6.	Oct. 7	...do..	122	139	Yes.	56.5	46 3	1.074	12.12	12.89	1 97	3 11	16,327	7.81
30.	White Mammoth	Row 7.	Oct. 8	...do..	282	139	Yes	143 5	50 9	1 078	Lost	13.96	1.35	2 91	33,333	9.70
	Oomseana.	Row 8.	Oct. 8	...do..	142.5	139	Yes	68.5	48 1	1.075	Lost.	12 83	1 72	2 93	17,852	8.18

EXPERIMENTS WITH SMALL MILL—*Continued.*

No. of experiment.	Variety.	Date of working.	Where grown.	Stripped weight, pounds.	Feet in row.	Suckered or not.	Juice, pounds.	Per cent of juice to stripped stalk.	Specific gravity of juice.	Polarization of juice.	Per cent of sucrose in juice.	Per cent of glucose in juice.	Per cent of solids in juice.	Stripped stalk per acre, pounds.	Per cent sucrose in juice available.
30.	Regular Sorgho .... Row 9.	Oct. 8.	Department of Agriculture.	175.5	139	Yes	90.5	51.6	1.071	10.21	11.08	2.91	2.72	21,383	5.45
	Link's Hybrid........ Row 10.	Oct. 8.	..do..	281	139	Yes	140	49.8	1.086	Lost.	16.29	.80	— 11	33,041	15.49
	Link's Hybrid........ Row 11.	Oct. 8	..do..	250	136	Yes	102.5	41.0	1.087	Lost.	16.78	.66	3.02	29,766	13.10
	Sugar Cane........ Row 12.	Oct. 8	..do..	280	138	Yes	136.5	48.8	1.088	Lost.	16.76	.74	3.18	32,103	12.84
	Goose Neck........ Row 13	Oct. 8	..do..	138	131	Yes	71	51.5	1.076	Lost.	12.62	2.39	2.97	18,045	7.26
	Bear Tail........ Row 14.	Oct. 8.	..do..	151.5	131	Yes	71	46.9	1.074	Lost.	12.58	3.16	2.32	20,461	7.10
	Iowa Red Top........ Row 15	Oct. 8	..do..	154.5	129	Yes	82	53.1	1.074	Lost.	13.82	1.74	2.17	20,643	9.91
31.	New Variety........ Row 16.	Oct. 10.	do..	191.5	132	Yes	86.5	45.2	1.079	Lost.	14.21	1.71	2.98	21,486	9.52
	Early Orange........ Row 17	Oct. 10.	..do..	255.5	133	Yes	136.5	53.4	1.078	13.62	13.92	1.92	2.38	30,634	9.62
	Early Orange........ Row 18.	Oct. 10	..do..	164	134	Yes	79	48.2	1.081	14.42	14.12	2.48	2.41	20,447	9.23
	Orange Cane........ Row 19	Oct. 10	do..	206	126	Yes	103	50.0	1.078	13.47	13.81	2.27	2.28	26,252	9.26
	Neeazana........ Row 20	Oct. 10	..do..	173.5	129	Yes	82	47.3	1.075	12.01	12.10	2.84	2.31	21,915	6.95
	Wolf Tail........ Row 21.	Oct. 10	..do..	218	129	Yes	124	50.0	1.077	13.72	14.11	1.33	2.75	30,683	10.03
	Gray Top........ Row 22.	Oct. 10	..do..	219	130	Yes	110	50.2	1.071	10.68	11.48	2.62	2.30	27,979	6.56
	Liberian........ Row 23.	Oct. 10	..do..	222	130	Yes	111.5	50.2	1.071	9.21	9.27	5.07	2.23	27,700	1.97
32.	Mastodon........ Row 24.	Oct. 11	do..	251.5	123	Yes	133	52.9	1.062	9.55	10.33	2.31	2.14	33,538	5.88
	Honduras........ Row 25.	Oct. 11	..do..	165.5	121	Yes	93.5	56.5	1.057	6.51	7.25	5.02	1.73	24,480	.50
	Sugar Corn........ Row 26	Oct. 11	..do..	115.5	118	Yes	57.5	49.8	1.063	8.68	9.72	3.52	1.90	17,215	4.30
	Wallis' Hybrid........ Row 27.	Oct. 11.	..do..	104.5	115	Yes	57.5	55.0	1.056	Lost.	7.19	5.09	1.87	17,184	.23
	White Imphee........ Row 28.	Oct. 11	..do..	125.5	112	Yes	63	50.2	1.068	11.09	13.52	1.55	2.06	19,382	9.91
	Goose Neck........ Row 29.	Oct. 11	..do..	53	109	Yes	26	49.1	1.063	10.09	11.21	2.43	2.44	10,750	6.34
	White African........ Row 30.	Oct. 11	do..	120	107	Yes	58.5	48.8	1.066	Lost	11.92	1.52	2.83	19,446	7.57
33.	Corn Stalks	Oct. 12	Dr. Dean	1,397			502.5	36.0	1.029	1.91	3.57	2.91	.71		— .05
34.	Early Amber	Oct. 13	H. Green	880			484	55.0	1.055	8.36	8.55	3.55	2.11	.....	2.89
35	Early Amber	Oct. 18	do..	1,560	..		780	50.0	1.059	7.57	8.16	4.75	1.82	.....	1.59
36	White Liberian	Oct. 19	..do..	2,590	..	.	1,246	48.1	1.069	9.31	9.50	5.44	1.57	.....	2.49
37.	Neeazana	Oct. 20	..do..	2,420	...	...	1,196	49.1	1.068	9.80	10.18	4.97	1.14	.....	4.07
38.	Link's Hybrid	Oct. 21	..do..	1,740		...	829	47.6	1.054	7.12	7.54	3.67	2.78	.....	1.09
39	Liberian	Oct. 22	..do..	980		.	496	50.6	1.054	3.70	6.06	7.02	1.10	.....	— 2.06
40	Honduras	Oct. 22	..do..	1,270		.	711	56.0	1.035	1.90	2.87	5.43	1.84	.....	— 4.40

EXPERIMENTS WITH SMALL MILL.

No. of experiment.	Temperature of defecation.	Hours in defecator.	Hours in evaporator.	Hours in defecator.	Pounds of water added.	Per cent of syrup to juice.	Juice lost.	Syrup made.	Polarization of syrup.	Per cent sucrose in syrup.	Per cent glucose in syrup.	Percent solids in syrup.	Per cent sucrose in syrup available.	Per cent sucrose of juice in syrup.	Per cent glucose of juice in syrup.
1	......	......	......	......	......	13.58	55	56	46.80	47.62	11.76	19.12	16.74	70.7	70.9
2	70° F.	1.3	2.3	......	......	27.65	None.	208	48.12	46.08	4.50	13.42	28.16	93.2	57.0
3	68	1.3	2.2	17	105	19.89	59.5	113	30.91	45.32	16.15	12.98	16.19	98.7	96.5
4	60	1.5	1.1	......	......	18.55	53	100.5	35.51	40.76	30.95	15.49	—5.68	101.0	112.1
5	70	.9	1.5	......	......	17.05	58	55	38.07	40.38	32.55	7.87	—.04	......	......
6	65	1.5	2.0	11.5	......	16.43	52.5	118	32.40	38.95	28.00	13.45	—2.50	98.5	78.3
7	65	1.2	2.3	......	......	18.30	51.5	121	29.48	31.83	32.50	10.67	—11.34	85.2	88.5
8	65	1.1	1.7	.7	63	20.77	49.5	78.5	43.74	50.35	18.00	8.45	23.90	95.2	90.2
9	65	1.1	2.3	1.0	210	25.50	75	132	43.42	47.98	7.20	19.22	21.56	97.2	116.2
10	65	.8	2.0	1.3	168	19.42	105	88	41.88	43.23	10.00	26.97	6.26	88.5	74.8
11	70	.9	2.0	......	......	19.57	47.5	79	......	55.86	8.25	12.49	35.12	86.3	82.8
12	50	.9	2.2	......	......	14.63	44.5	88	40.80	47.98	22.75	14.27	10.96	81.4	91.0
13	60	1.1	2.5	.9	168	20.64	132	138	42.85	44.15	10.25	15.60	18.30	78.6	70.1
14	50	1.1	2.2	14.5	......	17.07	62.5	111	?5.43	?17.50	50.50	?12.50	—45.50	80.6	77.7
15	53	.9	2.7	......	......	20.30	74	157.5	16.20	18.24	39.35	14.61	—35.72	99.3	73.6
16	41	1.2	2.3	16.9	......	18.98	139.5	299.5	8.67	9.50	59.00	19.10	—68.60	......	......
17	54	1.2	......	......	168	16.79	60	97.5	45.85	46.08	20.50	19.22	6.36	80.5	105.2
18	45	1.2	4.8	1.0	126	18.95	105.5	227.5	30.94	38.29	28.20	13.91	—3.82	119.4	69.9
19	56	1.3	2.5	15.3	126	16.64	54	104.5	36.05	38.00	18.00	15.40	4.60	75.5	71.8
20	50	1.3	3.5	.5	105	18.39	53.5	202.5	19.20	19.76	38.20	14.24	—32.68	64.0	118.6
21	50	1.5	3.5	.8	105	17.81	56	192	12.96	17.39	45.75	12.26	—40.62	78.2	80.5
22	68	1.3	3.6	15.5	......	16.81	80.5	169	14.58	22.14	41.75	4.51	—24.12	44.4	31.1
23	58	1.5	4.0	15.5	......	19.07	108.5	201	24.71	30.50	37.00	5.70	—12.20	80.1	99.4
24	50	1.2	3.5	1.0	105	22.26	58	222	5.43	14.73	49.50	16.17	—50.94	122.8	92.4
25	40	1.5	2.8	......	......	25.99	57	232.5	27.54	24.51	30.75	12.74	—18.98	90.8	110.8
26	40	1.3	2.5	16.0	......	14.52	50.5	101	35.23	36.39	34.40	12.21	—10.22	76.0	83.1
27	35	1.0	2.3	......	......	12.78	122.5	128.5	42.30	54.63	15.55	14.02	25.06	102.9	68.2
28	58	1.9	5.5	.7	147	16.46	129.5	194	51.19	53.87	14.35	19.18	20.34	80.5	71.1
29	60	1.3	3.3	14.2	......	17.14	122	104	55.40	59.85	6.50	17.45	35.90	69.9	69.7
30	54	1.7	2.7	1.0	126	22.60	164.5	167.5	59.50	59.09	7.00	16.91	35.18	93.3	102.8
31	40	1.3	2.9	.8	147	19.70	89	146.5	54.50	58.90	9.00	12.50	37.40	90.15	70.69
32	50	1.3	1.5	.9	63	18.60	59	80	45.28	45.60	12.50	12.90	20.20	85.3	74.8
33	42	1	1.7	......	......	10.23	53	46	20.25	25.46	20.75	14.39	—9.68	70.3	72.9
34	43	1	1.5	......	......	15.19	76	62	48.60	48.26	18.25	12.49	17.52	85.8	78.1
35	44	1.3	2.5	.5	84	15.53	123.5	102	46.98	48.36	22.65	10.79	14.92	92.1	74.1
36	......	......	......	......	......	......	123	186	44.14	47.03	20.50	7.87	18.66	82.0	62.4
37	......	......	......	......	......	......	159	186.5	50.46	49.69	22.25	16.06	11.38	87.8	80.5
38	......	......	......	......	......	......	106	149	44.63	45.89	21.75	17.76	6.38	125.5	122.1
39	......	......	......	......	......	......	82	54.5	28.43	31.35	40.10	1.95	—10.70	68.3	75.3
40	......	......	......	......	......	......	48.5	72	18.31	26.79	44.35	12.86	—30.42	101.5	88.7
													Average	87.5	82.7

In 1879 there were made at the Department of Agriculture, with the same apparatus already described for the small mill, 33 experiments in making sugar from cornstalks, sorghums, pearl millet, etc., in all of which there were used over 23 tons of stalks. The result of these experiments was to fully confirm all the experiments of the previous year not only, but to help toward the solution of certain questions of the highest practical importance. In every case, it was found that the quality of the syrup obtained was precisely such as the previous analysis in the laboratory of the juice used made probable. An average of the nine best syrups obtained, showed a percentage of cane sugar present equal to 92.7 of the amount originally present in the juice, while an average of the nine poorest (*i. e.*, containing the lowest percentage of cane sugar), showed a percentage of cane sugar present equal to 90.1 of the amount present in the juice.

Below are given the detailed results of the 33 experiments, and analyses of the juices from which these syrups were made. These stalks were obtained from neighboring farmers, and, as will be seen, were never in the condition best suited for working—but the results obtained from them are, however, of great practical value, and are given in detail.

The last column represents the relative loss of sucrose in making syrup, as compared with the glucose present, but gives no indication as to the absolute loss which may have been incurred; and since the economical production of sugar largely depends upon the amount of this loss, this matter is discussed more fully in another place.

EXPERIMENTS WITH

	Date of experiment.	Pounds of raw stalks.	Leaves and tops.	Tops.	Stripped stalks.	Topped stalks.	Juice expressed.	Specific gravity of juice.	Per cent of juice in raw stalks.	Per cent of juice to stripped stalk.
Early Amber sorghum, topped but not stripped	Sept. 18	1,603	....	234	.....	1,369	684	1057	42.67	....
	Sept. 24	2,566	.....	395	......	2,171	1,063	1060	41.43	.....
	Sept. 30	2,436	....	329	....	2,107	975	1057	40 02	.....
	Oct. 1	1,778	.....	258	......	1,520	660	1061	37.12	....
	Oct. 21	891	....	131	...	760	382½	1068	42.93	....
Honduras sorghum, topped and stripped.	Oct. 9	556	88	..	468	....	229	1072	41.01	48.93
Honduras sorghum, topped but not stripped.	Oct. 25	281	. .	10	......	271	113	1077	40.21	....
Honduras sorghum, topped and stripped.	Nov. 1	1,405	231	...	1,174	....	666	1058	47.40	56 73
	Nov. 3	1,231	117	.	1,114	.....	611	1058	49.63	54 85
	Nov. 4	1,431	155	.	1,276	......	660	1054	46 1[illegible]	51 72
	Nov. 6	3,368	385	...	2,983	.....	1,608	1055	47.74	53 91
Chinese sorghum, topped and stripped.	Sept. 23	319	76	....	243	......	111	1066	34.80	45 68
Chinese sorghum, topped but not stripped.	Oct. 2	296	.....	49	.....	247	139	1060	46 96	....;
	Oct. 11	1,679	.....	187	.....	1,492	542	1060	32.28	.....
	Oct. 25	1,709	.....	245	......	1,464	562	1058	32 88	.....
Liberian sorghum, top-and stripped.	Aug. 28	.	.....	....	.....	.....	20	...	...	.....
	Nov. 7	2,544	454	..	2,090	.....	1,090	1072	36.66	48.28
Pearl millet, topped and not stripped.	Oct. 2	378	.....	31	.....	347	106	1047	28 04	. ...
	Oct. 10	437	.....	44	.. ..	393	131	1047	30.00	...
Field corn, topped and stripped.	Sept. 29	222	67	....	155	.. ..	70	1070	31.53	45 16
	Oct. 4	1,969	667	....	1,302	...	494	1035	25 09	37.94
	Oct. 7	1,519	493	....	1,026	.....	384	1043	25 28	37 43
	Oct. 8	1,498	472	....	1,026	. ...	395	1010	26.37	38 50
	Oct. 13	....	...	..	1,095	....	332	1038	..	30.32
Egyptian sugar-corn, topped and stripped.	Sept. 11	621	240	...	381	.....	159	1063	25.60	41.73
Stowell's Evergreen corn, topped and stripped.	Oct. 16	3,435	1,035	....	2,400	......	1,123	1042	32 69	46.79
	Oct. 17	4,185	1,261	....	2,924	. ...	1,395	1042	33.33	47.71
	Oct. 18	1,968	593	....	1,375	.....	612	1044	31.10	44 51
Miller's sweet corn, topped and stripped.	Sept. 17	760	281	..	479	.....	214	1042	28 16	44 68
	Sept. 18	1,407	527	....	880	....	445	1051	31.63	50.57
	Sept. 19	1,191	441	...	750	.....	254	1051	21.33	33.87
Miller's sweet corn, topped and not stripped.	Sept. 20	821	.....	111	.....	710	268	1048	32.64	.....
	Sept. 25	1,001	.....	154	....	847	294	1047	29.40	....

/

SMALL MILL IN 1879.

Per cent of sucrose in juice.	Per cent of glucose in juice.	Pounds of syrup obtained.	Per cent of syrup in raw stalks.	Per cent of syrup in juice.	Polarization of syrup.	Sucrose in syrup by analysis.	Glucose in syrup by analysis.	Per cent of total solids in juice.	Per cent of glucose in juice.	Per cent of sucrose in juice.	Polarization of juice.	Relative loss of sucrose in making syrup.
8.70	4 30	98 5	6.15	14.40	46.4	....	....	13.01	4 30	8 70	....	....
11 10	3.10	154 0	6 00	14 49	48 0	51 1	29 6	....	3 10	11 10	11.43	14.9
11 10	3 50	169.1	6 94	17 16	44 3	42.3	20 6	15.41	3.50	11 10	10 50	8 7
11 60	3.70	102 8	5 78	15.67	51 2	56 6	25 2	15 35	3 70	11.60	10 50	6 6
11 91	2 63	58.0	6.51	15 17	58 3	62 9	18.7	......	2 63	11 91	......	4 8
12.30	2.50	41 2	7 41	18 00	51.8	60.9	16.8	16.57	2 50	12.30	11 80	4.7
10.49	1.14	15 5	5 52	14.40	61.0	70.2	8 6	17.38	1.14	10.49	....	1 1
9 24	3.63	97 5	6 94	14 65	37 2	36 4	31.7	13 62	3 63	9 24	......	18 4
7.70	5 10	88 5	7 19	14 47	38 1	46 3	32 9	13 49	5 10	7 70	.....	1 7
5 40	5 40	86 8	6 07	13 16	30 4	39 3	36 1	12.18	5 40	5.40	....	....
6.60	5.00	221.5	6.58	13 77	33 4	33.4	33.1	....	5.00	6 60	....	6 7
11.30	2.80	17 3	5 43	15.60	57 4	57.9	16 4	....	2.80	11 30	......	2 2
11.60	2.30	20.0	6 76	14 39	46.3	54 4	18 3	16 46	2.30	11 60	8 90	8 7
5 58	8 06	74 9	4 46	13 82	26.3	27 8	57 5	15.18	8 06	5 58	4.80	8 3
5.01	4.89	77.7	4.55	13.82	36 0	35.8	39.1	......	4 89	5 01	....	2.8
....	....	....	....	....	....	....	....	......	......	....	....	....
10.54	4 62	186 4	7.33	18 47	48 0	47 5	24 2	....	4.62	10 54	....	3 3
6.60	1 60	10.2	2.71	9 66	39 3	47 2	17 2	15.16	1 60	6 60	4 60	7 2
6.36	1 49	12 4	2.84	9 48	41.4	46 8	12 7	10 03	1 49	6.36	3.50	2 3
10.90	2.40	9 5	4.28	13 56	52 7	62 0	12 6	15 01	2 40	10 90	10 05	....
5 40	2.30	46 0	2 34	9 31	36 9	48 1	23 9	9.43	2 30	5 40	4 06	3 3
4 80	3.70	39 6	2.61	10 31	27 3	39 8	31 3	..	3 70	4 80	....	.5
5.10	3 80	40 5	2.71	10 26	21.4	34 5	36.4	18.79	3 80	5.10	......	8.6
2.70	4.48	36 1	....	10 87	18 5	25.5	42.0	8 07	4 48	2 70	....	.0
8.25	2.85	30 3	4.89	19 08	52 9	.....	.....	......	2.85	8.25	....	....
8.28	1.19	132 0	3 84	11.75	37 8	20 9	26 1	11.91	1 19	8.28	......	42 9
7.35	1.25	157.3	3.76	11 27	11 5	18 8	41 6	11.24	1 25	7.35	5.10	54 4
.....	......	68 8	3 50	11 25	44 3	46 7	17.2	......	...	......	....	....
5 20	3.80	24 2	3.21	11 39	38.1	45 3	31 2	......	3.80	5.20	....	.0
7.40	4.20	57 6	4.09	12 94	38 1	45.3	31.2	16.24	4.20	7.40	....	4.6
7.90	4.50	48.8	4.10	19.23	38.1	45.3	31.2	......	4.50	7.90	....	4.5
....	...	31 9	3 88	11.88	38.1	45.3	31 2	......	....	....	....	....
6.50	3.70	33.0	3.31	11.24	38 7	44.9	30.9	9.39	3 70	6 50	......	4.5

The experiments of 1879 doubtless explain some of the results of the previous year; since it is probably true that, owing to the immaturity, the tops had not yet attained their maximum content of sugar. A study of the previous tables giving results of the analysis of sorghums shows that up to a certain period the lower half of the cane is the best, but that this does not remain true of the sorghum, as it does of the sugar-cane in Louisiana, since the sorghum does have time to completely mature, which is not so with the sugar-cane in our country.

In the following table there have been calculated from the results given of the experiments in the making of sugar the following:

1st. The percentages of the sugar present in the juices operated upon, which were obtained in the syrup.

2nd. The percentage of crystallizable sugar (sucrose) present in the juices, which was obtained in the syrup.

3rd. The percentage of uncrystallizable sugar (glucose) present in the juices, which was obtained in the syrup.

4th. The percentage of crystallizable sugar present in the juices, which was inverted by the process of manufacture.

5th. The percentage of uncrystallizable sugar (glucose) destroyed during the process of manufacture.

The presence of the same relative proportions of crystallizable and uncrystallizable sugar in a syrup to those present in the juice from which this syrup has been prepared, by no means implies that there has been no inversion of the crystallizable sugar; for the destructive action of an excess of lime upon glucose is well known, and is not unfrequently made available in the production of sugar. Hence, it often happens that the relative quantity of crystallizable sugar in the syrup may be greatly in excess of that present in the juice, even after a large quantity of the crystallizable sugar has been destroyed by inversion. It is only possible, then, to determine the character of the changes which have taken place in the sugars during the process of manufacture, by quantitatively detetermining the amounts of sucrose and glucose in the juices and in the syrups prepared from them.

Since, obviously, this is a question of the greatest practical importance, as bearing upon the profitableness of the production of sugar from corn stalks or sorghum, the tables following will be studied with interest.

As in the previous table, there is a constant but not uniform discrepancy between the polarization of the syrups and the amount of crystallizable sugar found present by analysis.

Almost invariably the amount of sucrose found is somewhat in ex-

cess of the amount indicated by the polariscope, and this variation is such as to forbid any supposition that it is the result of error in observation or in analytical work.

This explanation may be found by consulting the following tables, in which it appears that, although there is generally about the same amount of glucose in the syrups relative to the amount present in the juice (averaging 97.1 per cent), there is still evidence of the destruction of an average of 35 per cent of the glucose. This destruction of glucose appears to be compensated, in part, by the inversion of a certain portion of the crystallizable sugar, and this inverted sugar possesses such action upon the polarized ray as to render the results of the polariscope practically worthless.

Practically, it appears that the proportion of crystallizable sugar present in the juice, which may be obtained in the syrup, depends greatly upon the condition of the stalks when worked. For, as will be seen, the average amount secured in all these experiments was but 77.1 per cent, still in those syrups prepared from canes which were in the proper condition the amount was over 90 per cent of the crystallizable sugar present in the juice operated upon. (See experiments, Nos. 6 and 7.) It is not improbable that even better results may be secured after further experiments shall have perfected the process of manufacture; but in view of the fact that such results have been attained with the crude and simple apparatus employed in the experiments here recorded, this result is highly gratifying.

We may hope, then, to secure in syrup 90 per cent of the crystallizable sugar present in the juice operated upon.

The results obtained in the experiments made with stalks from Stowell's Evergreen Sweet Corn are most remarkable and demand explanation. The juice obtained from these stalks gave in the laboratory excellent results, and promised a syrup of fine quality. By reference to the tables it will be seen, however, that these syrups (see experiments, Nos. 26 and 27) were wholly abnormal and very disappointing. These stalks were cut in Frederick, Md., October 11th, packed in a close car, and, through an oversight, allowed so to remain during oppressively hot weather until the 15th. They were worked up on the 16th, 17th, and 18th. Upon their arrival at Washington they were found so heated as to render their removal from the car even difficult, and yet the juice expressed from them appeared of excellent quality, but every attempt to produce from it a crystallizable syrup failed. An analysis of the syrup shewed that a very large percentage of the sugar had been inverted (in experiments, Nos. 26 and 27), and that the destruction of glucose in the syrup had been unusually large, while the

amount of crystallizable sugar present in the juice, and recovered in the syrup, was less than 30 per cent.

A few of the results attained appear to be only explicable upon the supposition that there have been slight errors in analysis; but revision of the work fails to reveal such errors, and the results are given in full, without omission, hoping that future investigation may solve difficulties which at present appear irreconcilable.

Number of experiments.	Per cent of sugars in syrup of amount present in juice.	Per cent of sucrose in syrup of amount present in juice.	Per cent of glucose in syrup of amount present in juice.	Per cent of sucrose inverted of amount present in juice.	Per cent of glucose destroyed in process of making.
1.	....	....	....	....	....
2.	82 3	66 7	138 3	33.3	0.0
3.	74 7	66 1	102 1	33.9	31.8
4.	83 3	76.0	106.0	24.0	18.0
5.	85 1	80 2	107 8	19 8	12.0
6.	94.4	89.1	120 9	10.9	....
7.	92.9	91 7	103.6	8.3	4.7
8.	77.4	57.7	127.7	42.3	14.6
9.	89 5	87.1	96 5	12 9	16.4
10.	91 8	55 7	90.7	4 3	13 6
11.	79 0	69 7	91 2	30 3	39.1
12.	82 1	79 8	91 3	20 2	28 9
13.	80.4	67 5	114 5	32 5	18 0
14.	86 4	68 9	98 6	31 1	32.5
15.	95.6	98 7	110 6	1 3	....
16.	....	....	....	....	....
17.	87 4	83 3	96 7	16.7	20.0
18.	75.5	68 8	103 5	31 2	27.7
19.	71 8	69 7	80 4	30.3	49 9
20.	76 1	77 2	71.3	22.8	51.5
21.	87.2	82 9	96 8	17 1	20.3
22.	86 3	85 6	87 2	14 4	27.2
23.	90.8	69 3	98.3	30.7	32.4
24.	....	....	....	....	....
25.	102 2	102 7	102.0	....	....
26.	58 3	29 7	25.8	70 3	144 5
27.	79.2	28 8	37.5	71.2	133 7
28.	....	....	....	....	....
29.	96 1	98 5	92.8	1 5	8 7
30.	85 4	79 2	96.1	20.8	24 7
31.	118 5	110 1	133.2	....	....
32.	....	....	....	....	....
33.	84.9	77.5	93 7	22.5	28.8
Average.	85.5	77.1	97.0	24.2	34.7

The committee of the National Academy of Sciences, in their report upon the "Sorghum Sugar Industry," p. 50, in reference to the experiments of 1879 and '81, the results of which have been given in the preceding tables, reports as follows:

Manufacture of Sugar from Sorghum.

From the numerous results given in Dr. Collier's reports, it is obvious that the method of manufacture of syrup was such that nearly all of the sugar present in the juices of the sorghum or maize could be secured in the syrup without inversion. This point is one of especial importance, practically, and, since the results differ so widely from those of other experimenters, they are entitled to careful consideration.

A single experiment of Dr. Goessmann gave, from a juice containing 8.16 per cent sucrose and 3.91 per cent glucose, a syrup containing 37.48 per cent sucrose and 37.87 glucose, or as follows:

	Per cent.
Juice:	
Sucrose	69.33
Glucose	30.67
Syrup:	
Sucrose	47.94
Glucose	52.06

From which it appears that, supposing there was no loss of glucose in the operation of making the syrup, 21.39 per cent of the sucrose was converted into glucose; or, in other words, 30.85 per cent of the sucrose in the juice was inverted. If such a result was to follow invariably, no one, we think, would hesitate to accept the following conclusion, drawn by Dr. Goesmann from the above experiment, viz.:

> In sight of these facts, it will be quite generally conceded that the sugar production from syrup like the above must remain a mere incidental feature in the Amber-Cane industry in our section of the country.

In 1879, the average of 24 experiments with the juices of several varieties of sorghum and maize, made at the Department of Agriculture (see Annual Report, 1879, p. 53), showed that the relative loss of sucrose in the syrup was only 5.35 per cent of that present in the juice, instead of being, as Dr. Goessmann found, 30.85 per cent.

But of far greater importance is the fact brought out in an average of 40 experiments, including all made, that there was an actual loss of only 12 5 per cent of the cane sugar; *i. e.*, there was secured as sugar in the syrup 87.5 per cent of all the sugar present in the juice; thus showing that even the total loss by defecation, by skimming, and by inversion, was no more than that usual with sugar-cane juice, for it is estimated that only about 80 per cent of the cane sugar present in the tropical juices is recovered in the sugar and molasses, a little over 20 per cent being lost in the manufacture.

In Ure's Dictionary, Appleton's edition, 1865, vol. II, p. 758, the writer upon sugar says as follows:

> The average quantity of grained sugar obtained from cane juice in our colonial plantations* is probably not more than one-third of the quantity of crystalline sugar in the juice which they boil.

Syrups and Sugar from the new Chinese Sorghums.

Although the new varieties of sorghum from China were far inferior

* British possessions.

as sugar producing plants to those received from India, Africa, or those grown in the United States, and those sending the seed confidently assured Minister Angell that there was no sugar to be obtained from these varieties, an experiment was made with the stalks of all of the six kinds, except No. 1 (which had been cut down), upon September 16th, with the following results:

Stalks, with tops and leaves	pounds	290
Stripped stalks obtained	pounds	160
Loss by topping and stripping	per cent	44 83
Juice expressed	pounds	76
Juice in stripped stalks	per cent	47.50
Juice lost	pounds	19
Syrup made from 57 pounds juice	pounds	9
Syrup in juice	per cent	15 79

Duplicate analyses of the above juice and syrup gave the following results:

Number of analysis.	Specific gravity.	Per cent sucrose.	Per cent glucose.	Per cent solids.	Per cent polarization.	Per cent available sugar.
Juice, 182	1 057	8.48	1.48	3 41	8.54	3.59
Juice, 183	1.057	8.45	1.49	3 09	8.52	3 87
Syrup, 206	1.038	5.72	.67	2 92	......	2 13
Syrup, 207	1 038	5.93	.69	2.48	......	2.38

In the above, 40 grams of syrup was diluted with 300 c. c. of water for the purpose of analysis.

It will be seen that, in the 57 pounds of juice used, there was, in pounds:

Sucrose	4.82
Glucose	.84
Solids	1 85
Available sugar	2.13

And in the 9 pounds of syrup made:

Sucrose	4.46
Glucose	.51
Solids	2.22
Available sugar	1.73

Or, there was recovered in the syrup of the amount present in the juice of:

	Per cent.
Sucrose	84.2
Glucose	60 8
Solids	119.8
Available sugar	81.3

There was nothing unusual in the character of this syrup. After a short time, it crystallized to a semi-solid mass.

It would appear, therefore, that the sole difference between these

Chinese sorghums and sorghums which have been examined heretofore is in the content of sugar and juice which these contain, and that there is no reason to doubt but that the better varieties could be substituted for them, care being taken to select only such varieties as would mature in the northern part of China, where, as Minister Angell informs me, these sorghums are grown much as maize is in this country, and for the same purpose.

It is interesting to observe that, in China, where for centuries the sorghums have been cultivated; in Turkistan, where, as Mr. Kuleshoff, of the Agricultural Academy of Moscow, informs me, sorghum is one of the leading crops; and in Africa and India, where it is the leading cereal, the chief value of this interesting plant has so long remained unknown.

THE CAUSES OF FAILURE IN THE MANUFACTURE OF SUGAR.

The results of these investigations and experiments conducted during the seasons of 1879 and 1881, serve to account satisfactorily for not only the failures at Washington, but for most of the failures of those who have attempted the manufacture of sugar from sorghum during the past thirty years.

As it is of vital importance that the causes of failure may be clearly understood, they will be briefly stated.

The chief sources of failure are as follows:

1. The immaturity of the sorghum at the period when it is cut and worked. This may be due to late planting, as in our experience in 1881, or to the selection of a variety which requires more time for its complete maturity than the season in any given latitude may give. The importance, then, of selecting only such varieties as will mature sufficiently long before frosts, to give a reasonable time for working the crop, can not be overestimated.

The time required for the several varieties to reach a good condition for sugar from the time of planting the seed, has been found from the results of experiments in 1880 and 1881, to be as follows:

TIME FROM PLANTING TO MATURITY, AND NUMBER OF DAYS FOR WORKING.

Varieties.	1881. Number of analyses.	1881. Days from planting to working period.	1881. Days for working.	1881. Average available sugar.	1880. Number of analyses.	1880. Days from planting to working period.	1880. Days for working.	1880. Average available sugar.	Average. Days from planting to working period.	Average. Days for working.	Average. Available sugar.
Early Amber	24	96	106	10 12	80	77	99	7.89	87	102	9 00
Early Golden	26	92	110	10.02	76	80	104	6.62	86	107	8 32
White Liberian	25	92	110	10.41	39	88	101	8.95	90	106	9.68
Do	25	92	110	10.61	....	....	....		92	110	10 61
Black Top	15	108	76	11.08	35	87	87	8 41	98	82	11.08
African	20	117	85	9.82	83	87	107	6 90	102	96	8 36
White Mammoth	9	122	42	10.60	32	102	83	8 88	112	63	9 74
Ocmseeana	15	109	75	10 76	54	115	77	7.60	112	76	9.18
Regular Sorgho	7	118	18	9.78	71	101	93	7 28	110	56	8.53
Link's Hybrid	21	96	106	11.02	30	101	84	9 88	98	95	9 95
Do	23	105	97	11.36	....	....	....	....	105	97	11.36
Sugar-cane	23	99	103	10 86	28	108	77	9.20	104	90	10 03
Goose Neck	6	122	16	11 34	44	111	72	7.81	117	44	9 58
Bear Tail	10	109	56	9.76	....	....	....	....	109	56	9.76
Iowa Red Top	13	104	70	12 64	....	....	....	....	104	70	12.64
New Variety	19	92	92	11.63	....	....	....	....	92	92	11 63
Early Orange	14	112	72	10.73	53	117	79	8.21	115	76	9.47
Do	19	116	86	9.91	....	....	....	....	116	86	9 91
Orange Cane	14	113	71	9.56	....	....	....	....	113	71	9.56
Neeazana	20	113	89	6 78	38	136	58	8.39	125	74	7.59
Wolf Tail	24	108	94	9.67	21	118	56	7 51	113	75	8.59
Gray Top	21	112	90	6.79	33	135	59	8.02	124	75	7.41
Liberian	7	126	38	8.55	22	131	38	7.91	129	38	8.23
Mastodon	9	123	41	8 66	23	128	60	6 53	126	51	7.60
Honduras	7	126	25	6 56	27	148	29	4 97	137	27	5 77
Sugar-cane	11	112	62	7.82	....	....	....	....	112	62	7.82
Hybrid, Wallis	4	119	8	9.45	....	....	....	....	119	8	9.45
White Imphee	8	108	56	11 90	....	....	....	....	108	56	11 90
Goose Neck	13	112	72	9 29	....	....	....	....	112	72	9.29
White African	20	103	97	8 21	....	....	....	....	103	97	8.21
West India Sugar-cane	8	107	49	10 70	....	....	....	....	107	49	10 70
Sugar-cane	4	131	23	8.76	....	....	....	....	131	23	8 76
New Variety	10	101	51	8.30	....	....	....	.	101	51	8 30
Early Amber	10	101	53	10 78	....	....	....	....	101	53	10.78
Honey Cane	2	139	15	7 68	21	133	43	5 73	136	24	6 71
Average	....	110	68	9.77	...	111	74	7.72	110	69	9.30

By reference to the experiments made with the small mill, and to the explanation of the failure in making sugar in the large mill, it will be seen that there was a difference of nearly 100 per cent between the per cent of available sugar in the juices of the suckered and unsuckered plats of sorghum operated upon. This difference was obviously due to the presence, along with the ripe cane, of a certain proportion of cane from suckers in different stages of immaturity, the juices from which, as we have seen, contained a minus amount of available sugar, and therefore diminished the yield otherwise attainable from the mature canes. So also with the crop for the large mill, the successive plantings of seed produced a lot of cane of almost every

degree of development, except that of complete ripeness; and the analyses of the juices and syrups showed a result which was anticipated. It is of importance, for the purpose of sugar production, that the crop of cane be not only ripe, but that it should be carefully suckered; or, if allowed to grow, these suckers should be carefully kept apart, in cutting the canes for the mill, and worked for syrup, for which alone they are suitable. It is possible that some varieties of sorghum may be found in which this tendency to throw up suckers from the roots is not so strong, and, other things being equal, such varieties are much to be preferred for sugar production.

It should be the aim, then, to secure a good stand of sorghum at the first planting, since the replanting of portions of the field would destroy the equality of the crop. Unless time should allow this second planting to mature, it would be far better to leave such portions of the field bare, unless this cane be reserved solely for syrup.

2. Another frequent cause of failure, is allowing the sorghum to remain some time after being cut before it is worked at the mill. That such a course may be pursued in certain seasons and localities without producing an unfavorable result, has been established beyond much doubt; but the climatic conditions which render such a procedure possible are imperfectly understood at present. Repeated experiments have demonstrated that, after the cane is cut, the juice is subject to chemical changes which speedily result in destruction of the crystallizable sugar. For the present, then, the only safe course to pursue is to work up the cane within, at most, 24 hours after it is cut up.

3. A third cause of failure exists in an imperfect method of defecation of the juice. The object of defecation, and the method by which it is accomplished, should be carefully studied and as thoroughly understood by the sugar-boiler as is possible. Although somewhat complex in its details, the general principles which underlie this important step are few and easily comprehended.

The juices of sorghum or of maize, like the juice of sugar-cane or of beets, contain, besides sugar, several other substances, the removal of which it is the object of defecation to accomplish. The more completely removal of these other substances is effected, the greater the percentage of the sugar present in the juice which may be obtained.

Among these impurities of the juice are certain organic acids and organic salts, nitrogenous matters, and salts of mineral acids, together with glucose and the mechanical impurities, as fragments of cane.

The universal practice among sugar-makers from sugar-cane is to add to the juice an amount of lime, generally as milk of lime, sufficient

to neutralize the free acid found in the juice, and then to heat the juice to boiling.

The effect of the lime is not only to neutralize the free organic acids, but to form with certain others of these impurities insoluble lime salts.

The effect of the heat is to coagulate certain of the nitrogenous substances present in the juice.

Upon allowing the juice which has been brought to the boiling point to stand a few moments, there will be found a heavy scum upon the surface, consisting largely of the coagulated matters which have mechanically entangled and brought to the surface the fragments of cane and other mechanical impurities of the juice. At the bottom of the defecator will be found a sediment, more or less abundant, composed largely of the lime salts formed, and which, generally being heavier than the juice, will soon settle to the bottom.

If, however, the juice is very dense, it will occasionally happen that this sediment will remain suspended in the juice, neither rising to the surface nor settling to the bottom. In such event, it will be found necessary to draw the juice, after skimming, into a cooling tank, or allow it to remain in the defecator until these impurities shall settle; or it may be hastened by adding to the juice, after skimming, enough cold water to dilute the juice, and diminish its density, so that the lime salts present may settle. By reference to the result of our experiments already given, it will be seen that this method may be pursued without loss of sugar.

After the subsidence of these impurities, the juice may be drawn from this sediment, and it will be, if the operation has been properly conducted, quite clear and almost colorless. It is then to be evaporated to a syrup as speedily as possible, and such additional impurities as rise to the surface, especially during the earlier stage in the evaporation, are removed by skimming.

The importance of removing all those impurities rendered insoluble by the action of the lime and heat combined, is manifest. If allowed to remain, it will be found that they are but imperfectly removed during evaporation, and remain to a great extent in the syrup, causing it to be muddy in appearance, impure in its composition, and disagreeable in quality.

APPENDIX.

The following statistics, as to the production of sugar, have been furnished by the Bureau of Statistics of the Treasury Department.

Quantities of sugar and molasses produced in the state of Louisiana during the years from 1850 *to* 1883, *inclusive.*

Year.	Sugar.		Molasses.
	Hogsheads.	*Pounds.*	*Gallons.*
1849–'50	247,923	269,769,000	12,000,000
1850–'51	211,203	231,194,000	10,500,000
1851–'52	236,547	257,138,000	18,300,000
1852–'53	321,934	368,129,000	25,700,000
1853–'54	449,324	495,156,000	31,000,000
1854–'55	346,635	385,227,000	23,113,620
1855–'56	231,427	254,569,000	15,274,140
1856–'57	73,976	81,373,000	4,882,380
1857–'58	279,697	307,666,700	19,578,790
1858–'59	362,296	414,796,000	24,887,760
1859–'60	221,840	255,115,750	17,858,100
1860–'61	228,753	265,063,000	18,414,550
1861–'62	459,410	528,321,500	*a.*
1862–'63	*a.*	*a.*	*a.*
1863–'64	76,801	84,500,000	*a.*
1864–'65	10,387	10,800,000	*a.*
1865–'66	18,070	19,900,000	*a*
1866–'67	41,000	42,900,000	*a*
1867–'68	37,364	41,400,000	*a.*
1868–'69	84,256	95,051,225	5,636,920
1869–'70	87,090	99,452,940	5,724,256
1870–'71	144,881	168,878,592	10,281,419
1871–'72	128,461	146,906,135	10,019,958
1872–'73	108,520	125,346,490	8,898,640
1873–'74	89,498	103,241,119	8,203,944
1874–'75	116,867	134,504,691	11,516,828
1875–'76	144,146	163,418,070	10,870,546
1876–'77	169,331	190,672,570	12,024,108
1877–'78	127,753	147,101,941	14,237,280
1878–'79	213,221	239,478,753	13,218,404
1879–'80	169,972	198,962,278	12,189,190
1880–'81	218,314	272,982,899	15,255,029
1881–'82	122,982	159,874,950	9,691,104
1882–'83	241,220	303,066,258	15,716,755

a No data.

NOTE.—The production of sugar and molasses in Louisiana is stated upon the authority of M. Champoiner for the period prior to 1861, and for the later years upon the authority of M. Louis Bouchereau and A. Bouchereau.

Quantities of sugar and molasses produced in the United States during the years 1869 and 1879, according to the census.

States.	Sugar.		Molasses.	
	1869.	1879.	1869.	1879.
	Hogsheads.	*Hogsheads.*	*Gallons.*	*Gallons.*
Alabama	31	94	166,009	795,169
Arkansas	92	....	72,008	....
Florida	952	1,273	344,339	1,029,868
Georgia	644	601	553,192	1,565,784
Louisiana	80,706	171,706	4,585,150	11,696,248
Mississippi	49	18	152,164	536,625
Missouri	49	....	....	....
North Carolina	35	....	33,888	....
South Carolina	1,055	229	436,882	138,944
Tennessee	1,410	....	3,629	....
Texas	2,020	4,951	246,062	810,605
Total	87,043	178,872	6,593,323	16,573,273

Production of Sugar.

Table showing the annual production of beet sugar during the last five crop years from 1874–5 to 1878–9.

[From "Journal de la Societe de Statistique, Paris, 1880.]

Country.	Pounds.
France	953,709,960
Germany	927,431,128
Austria-Hungary	894,847,140
Russia	473,989,000
Belgium	154,145,632
Netherlands	55,115,000
Sweden, Norway, Italy	11,023,000
Total 1878–1879	3,470,260,860
Total 1877–1878	3,131,634,300
Total 1876–1877	2,471,764,451
Total 1875–1876	3,025,637,132
Total 1874–1875	2,616,948,384

For certain countries the export is given as being more exactly known than the production.

	Pounds.
EUROPE.	
Spain	33,069,000
ASIA.	
French Cochin China (production)	55,115,000
China (export)	55,115,000
Japan "	33,069,000
Siam "	11,023,000
Hindostan and British East Indies (export)	55,115,010
" " " (product consumed)	3,196,670,000
Total	3,406,107,000
AFRICA.	
Egypt (production)	66,138,000
Mauritius (export)	297,621,000
Mayotta, Nossi Bé (export)	8,818,400
Natal	17,636,800
Bourbon Islands (export)	66,138,000
Madagascar	7,716,100
	464,068,300
AMERICA.	
Antilles, or West Indies.	
Cuba (production)	1,421,967,000
Porto Rico (export)	198,414,000
Jamaica (export)	44,092,000
Hayti and Lucayos	11,023,000
Total	1,675,496,000
LESSER ANTILLES.	
Gaudeloupe (export)	110,230,000
Martinique "	88,184,000
Trinidad "	125,662,200
Barbadoes "	119,048,400
Antigua "	15,432,200
St. Christopher "	11,023,000
St. Lucia "	11,023,000
St. Vincent "	13,227,600
Others "	41,887,400
Total	535,717,800
GUIANA.	
Demerara Berbice (export)	209,437,000
Surinam (export)	20,943,700
Cayenne "	2,204,600
Total	232,585,300
OTHER COUNTRIES.	
Brazil (export)	266,536,140
Louisiana "	231,483,000
Peru "	187,391,000
Mexico "	66,138,000
Canada "	11,023,000
California "	11,023,000
Argentine Republic (export)	11,023,000
Total	784,617,140
Grand Total America	3,228,416,240

	Pounds.
Oceanica.	
Java (export)	475,091,300
Manilla "	264,552,000
Australia "	44,092,000
Sandwich Islands (export)	27,557,500
Others (export)	9,920,700
Total	821,213,500
General total 1878–1879	7,952,874,040
Seasons 1877–1878	7,605,870,000
Seasons 1876–1877	7,475,798,600
Seasons 1875–1876	7,374,387,000
Seasons 1874–1875	7,605,870,000

Sugar Crop, 1880.

The production of cane sugar throughout the world, for the crop year ending in 1880, will certainly exceed 4,000,000 tons, or 8,960,000,000 pounds of cane sugar produced, approximately, as follows, according to the most reliable statistics and reports:

(From "Concise Resumé," by Henry A. Brown, 1880.)

Countries.	Tons.
British India	1,550,000
Cuba, Porto Rico	700,000
Other Spanish Possessions	50,000
Br. W. I., Demerara, etc	250,000
China, Hong Kong, etc	250,000
Dutch Ind., Java, etc	220,000
French W. I., Guiana	175,000
Brazil, S. A., etc	130,000
Louisiana	125,000
Mauritius	125,000
Philippine Islands	120,000
Egypt, etc	75,000
Peru, S. A., etc	55,000
Mexico	35,000
Other Countries	140,000
Total Cane Sugars	4,000,000

In addition to cane sugar, it is estimated that the production of maple, palm, and sorghum sugars, in the crop year ending in 1880, will exceed 150,000 tons, and the amount of beet root sugar produced in Europe the present crop year is estimated at 1,670,000 tons, apportioned as follows:

Countries.	Tons.
Germany	500,000
France	425,000
Austria	410,000
Russia, Poland.	225,000
Belgium, Holland, etc	110,000
Total beet	1,670,000

Total Known Production of Sugars—Crop for Year Ending in 1880.

	Tons.
Cane sugar	4,000,000
Beet, Europe	1,670,000
Maple, etc	150,000
Total sugar	5,820,000

There are, however, good reasons for believing that the world's annual production of cane and similar sugars exceeds 6,000,000 (six millions) of tons, and that China, from whence sugar-cane first found its way to Europe, alone produces enough more sugar than she reports to more than justify such statement.

Sugar Crop, 1881.

[From the "Concise Resumé of Sugar Tariff Topics, in Defense of American Sugar Industries," etc., 1882. By H. A. Brown.]

Genuine and authentic information from sugar producing countries, indicates that the annual cane sugar crop of the world exceeds 4,900,000 tons, and is produced, approximately, as follows:

Countries.	Tons.
British India	1.500,000
China, Hong Kong, etc	1,000,000
Cuba and Spanish Possessions	750,000
British West Indies, Demerara, etc.	250,000
Dutch India, Java, etc	250,000
French West Indies, Guiana, etc.	175,000
Brazilian Empire	175,000
Mauritius, Reunion, etc.	150,000
Manilla, Philippine Islands	135,000
Louisiana, Texas, etc	125,000
Egyptian Provinces	75,000
Peru, South America	75,000
Hawaiian Islands	45,000
Mexico	35,000
All other countries	160,000
Total cane sugar ... tons	4,900,000

Added to the cane sugar crop of 1881 will be the beet sugar crop of Europe, about 1,700,000 tons, and minor crops of maple, palm, beet, and sorghum sugars, in this and other countries, estimated at 100,000 tons.

Total known and estimated sugar crop of 1881:

	Tons.
Cane sugar	4.900,000
Beet sugar, Europe	1,700,000
Maple, sorghum, etc.	100,000
Total sugar crop ....tons	6,700,000

Sorghum Sugar in New South Wales.

In a letter recently received from Mr. A. Fairgrieve, President of the Colonial Sugar Refinery Company, Sydney, New South Wales, he gives the following data of experiments in sugar production, from two varieties of sorghum, which he calls the "Black" and the "Yellow." He had not enough of the Yellow variety for experiments in sugar making, but obtained a yield of 6 to 9 tons of stalks to the acre, and of 1,200 to 1,800 pounds of seed to the acre.

From 690 pounds of stalks, "cut just as the seeds were beginning to harden," he obtained 38½ gallons of juice, the mill giving, at the first pressure, 30 gallons, and the bagasse, being again passed through the mill, yielded 8½ gallons additional.

After defecation with lime, the juice had a density of 10° Beaumé, at 80° F., and only 31 gallons of defecated juice were worked for syrup and sugar.

From the 31 gallons of juice, 41 pounds of masse cuite were obtained, which gave, of first sugars, 12½ pounds, and, of second sugars, 5½ pounds, leaving 23 pounds of molasses.

It will be seen that the mill gave only 48 per cent of the weight of the stalks in juice, but the syrup yielded 44 per cent of sugar and 56 per cent of molasses.

The products, then, from each ton of cane, was

52.2 pounds of sugar.
5.33 gallons of molasses.
5.36 bushels of seed.

But, as the mill gave only 48 per cent of juice, while 60 should be given by a suitable mill, and since only 80 per cent of the juice extracted was used in making syrup, the above results, with a good mill,

and without such unnecessary loss of juice, would have been, for each ton of cane worked, a product of

81.6 pounds of sugar.
8.33 gallons of molasses.
5.36 bushels of seed.

The above results are very interesting, as evidence that, even in far distant lands, the sorghum maintains its character as a sugar producing plant. That the product of sugar would have been much increased, by allowing still greater maturity of the crop to be attained, can hardly be doubted, in view of the numerous results recorded.

The following analyses of the two varieties of sorghum, of the ash, as also of the sugars, molasses, and the ash of the molasses, are furnished by Mr. Fairgrieve, and are of interest in connection with the above results:

Analyses of Six Samples of Sorghum (Dried, 212° F.)

	Black Sorghum.			White Sorghum.		
	Top.	Middle.	Bottom.	Top.	Middle.	Bottom.
Cane sugar	30.92	31 60	31.70	25 31	33.89	29.48
Fruit sugar	5 06	5.22	5.19	10 46	10 70	10 68
Dextrine and starch	8.67	8.56	8 58	1 59	2 29	2 89
Woody fiber	43 95	44.96	44 10	53.42	44.33	46 39
Other organic matters	6 73	5 02	5 89	3 05	4 30	5 69
Soluble ash	3.26	3 19	3 14	4 10	3 49	3 59
Silica	1.41	1.45	1.40	2 07	1.00	1.28
	100.00	100.00	100.00	100.00	100 00	100 00

The ash consisted of:

Potassium	1.14	1.20	1.17	1.60	1 25	1.24
Sodium	.22	.21	.20	.38	.34	.37
Oxygen (comb'd P. & S.)	.07	.08	.08	.12	.09	.09
Lime	.28	.26	.26	.34	.28	.29
Magnesia	.23	.21	.22	.29	.22	.24
Iron and Al. phosphates	.15	.12	.14	.18	.13	.13
Phosphoric acid	.31	.29	.29	.39	.32	.38
Sulphuric acid	.18	.17	.15	.18	.17	.17
Chlorine (comb'd P. & S.)	.68	.65	.63	.62	.69	.68
Silica	1.41	1.45	1.40	2 07	1 00	1 28
	4.67	4.64	4.54	6.17	4.49	4.87

Analyses of Sugar and Molasses Obtained from Black Sorghum.

	No. 1 sugar.	No. 2 sugar.	Molasses.
Cane sugar	87.00	84 20	44 40
Fruit sugar	2.33	3.34	12 07
Dextrine and starch	2.47	.89	.66
Other organic matters	2.08	3.69	10 64
Soluble ash	2.11	2.95	9.23
Sand	.11	.03	.00
Water	3.90	4.90	22.50
	100 00	100.00	100.00

Analysis of Ash of Molasses.

	Per cent.
Potassium	3.16
Sodium	.93
Oxygen (comb'd P. & S.)	.65
Lime	.95
Magnesia	.91
Iron peroxide	.C6
Alumina	.06
Copper oxide*	.02
Phosphoric acid	.87
Sulphuric acid	.28
Chlorine (comb'd P. & S.)	1 27
Silica	.07
	9.23

Amabele.

In a recent letter from Leonard Wray, who first introduced the sorghums from Africa into the United States, he writes: "The Zulu name, '*Imphee*,' is the sugar producing sorghum; whereas '*Balee*,' or '*Ma-balee*,' is the name for '*Dhura*' or Kaffir corn (Sorghum vulgare)." He also says '*En-ya-ma*' means *food*, the grain of which makes such good flour; and he advises that the sorghum should be sown in triple rows, four feet from center to center, the triple rows being 8 inches apart, and the stalks 7 inches apart in each row, equal to 55,640 canes to the acre.

Sorghum Sugar produced in 1883.

According to the statement of the President of the Mississippi Valley Cane Growers' Association, there was produced at the Champaign, Ill., Sorghum Sugar Works, from 145 acres, 1,435 tons of cane; and from 2,400 tons of cane, there was obtained 160,000 pounds of sugar and 40,000 gallons of molasses.

The season is described as being the most unfavorable for thirty years.

At Hutchinson, Kansas, some 200,000 pounds of sugar, besides a large quantity of molasses.

*Probably from vacuum pan or battery.

At Sterling, Kansas, some 200,000 pounds of sugar, besides the molasses.

At Dundee, Kansas, 10,000 pounds of sugar, though their product was mainly syrup, of which 50,000 gallons were made.

At Kinsley, Kansas, 10,000 pounds of sugar, and a large quantity of syrup.

At Lawrence, Kansas, some 10,000 pounds of sugar.

At Rio Grande, N. J., 282,711 pounds of sugar, and 55,000 gallons of molasses. A large portion of their cane failing to ripen, owing to the unusual season.

The Secretary of the Kansas State Board of Agriculture reports the following summary of the year 1883 for Kansas:

Acres planted in sorghum	102,042
Acres manufactured into syrup	48,271
Acres planted for forage	53,771
Tons of cane manufactured	447,859
Gallons of syrup made	4,684,023
Value of syrup made	$2,058,127.60

The entire number of counties reporting was 81, and of these,

32	grew from	50	to	500	acres
20	"	500	"	1000	"
10	"	1000	"	2000	"
10	"	2000	"	3000	"
5	"	3000	"	4000	"
4	"	4000	"	8000	"

10 counties produced over 100,000 gallons of syrup each, and 2 counties produced over $100,000 worth of syrup each, while 17 counties produced each over $30,000 worth of syrup.

The value of syrup averaged from each acre $42.65, without counting the product of seed. The yield averaged 9.3 tons of cane per acre.

INDEX.

PUBLICATIONS
OF
ROBERT CLARKE & CO.

JULY, 1883. CINCINNATI, O.

HISTORICAL AND MISCELLANEOUS.

ALZOG (John D. D.) A Manual of Universal Church History. Translated by Rev. T. J. Pabisch and Rev. T. S. Byrne. 3 vols. 8vo. 15 00

ANDERSON (E. L.) Six Weeks in Norway. 18mo. 1 00

ANDRE (Major). The Cow Chase; an Heroick Poem. 8vo. Paper. 75

ANTRIM (J.) The History of Champaign and Logan Counties, Ohio, from their First Settlement. 12mo. 1 50

BALLARD (Julia P.) Insect Lives; or, Born in Prison. Illustrated. Sq. 12mo. 1 00

BELL (Thomas J.) History of the Cincinnati Water Works. Plates. 8vo. 75

BENNER (S.) Prophecies of Future Ups and Downs in Prices: What Years to Make Money in Pig Iron, Hogs, Corn, and Provisions. 2d ed. 24mo. 1 00

BIBLE IN THE PUBLIC SCHOOLS. Records. Arguments, etc., in the Case of Minor *vs.* Board of Education or Cincinnati. 8vo. 2 00

Arguments in Favor of the Use of the Bible. Separate. Paper, 50

Arguments Against the Use of the Bible. Separate. Paper, 50

BIBLIOTHECA AMERICANA. 1883. Being a priced Catalogue of a large Collection (nearly 7,000 items) of Books and Pamphlets relating to America. 8vo. 312 pages. Paper, 50c.; Cloth, 1 00

BIDDLE (Horace P.) Elements of Knowledge. 12mo. 1 00

BIDDLE (Horace P.) Prose Miscellanies. 12mo. 1 00

BOUQUET (H.) The Expedition of, against the Ohio Indians in 1764, etc. With Preface by Francis Parkman, Jr. 8vo. $3.00. Large paper, 6 00

BOYLAND (G. H., M.D.) Six Months Under the Red Cross with the French Army in the Franco-Prussian War. 12mo. 1 50

BRUNNER (A. A.) Elementary and Pronouncing French Reader. 18mo. 60

BRUNNER (A. A.) The Gender of French Verbs Simplified. 18mo. 25

BURT (Rev. N. C., D.D.) The Far East; or Letters from Egypt, Palestine, etc. 12mo 1 75

BUTTERFIELD (C. W.) The Washington-Crawford Letters; being the Correspondence between George Washington and William Crawford, concerning Western Lands. 8vo. 1 00

BUTTERFIELD (C. W.) The Discovery of the Northwest in 1634, by John Nicolet, with a Sketch of his Life. 12mo. 1 00

CLARK (Col. George Rogers). Sketches of his Campaign in the Illinois in 1778–9. With an Introduction by Hon. Henry Pirtle, and an Appendix. 8vo. $2 00 Large paper, 4 00

COFFIN (Levi.) The Reminiscences of Levi Coffin, the Reputed President of the Underground Railroad. A Brief History of the Labors of a Lifetime in behalf of the Slave. With Stories of Fugitive Slaves, etc., etc. 12mo. 2 00

COLLIER (Peter). Sorghum: its Culture and Manufacture Economically Considered, and as a Source of Sugar, Syrup and Fodder. Illustrated. 8vo. 3 00

CONSTITUTION OF THE UNITED STATES, ETC. The Declaration of Independence, July 4, 1776; the Articles of Confederation, July 9, 1778; the Constitution of the United States, September 17, 1787; the Fifteen Amendment to the Constitution, and Index; Washington's Farewell Address, September 7, 1796. 8vo. Paper. 25

CORNWELL (H. G.) Consultation Chart of the Eye-Symptoms and Eye-Complications of General Disease. 14 x 20 inches. Mounted on Roller. 50

CRAIG (N. B.) The Olden Time. A Monthly Publication, devoted to the Preservation of Documents of Early History, etc. Originally Published at Pittsburg, in 1846–47. 2 vols. 8vo. 10 00

DRAKE (D.) Pioneer Life in Kentucky. Edited, with Notes and a Biographical Sketch by his Son, Hon. Chas. D. Drake. 8vo. $3 00. Large paper. 6 00

DUBREUIL (A.) Vineyard Culture Improved and Cheapened. Edited by Dr. J. A. Warder. 12mo. 2 00

ELLARD (Virginia G.) Grandma's Christmas Day. Illus. Sq. 12mo. 1 00

Everts (Orpheus). What Shall We Do With the Drunkard? A Rational View of the Use of Brain Stimulants. 8vo. Paper. 50

Family Expense Book. A Printed Account Book, with Appropriate Columns and Headings, for keeping a Complete Record of Family Expenses. 12mo. 50

Finley (I. J.) and Putnam (R.) Pioneer Record and Reminiscences of the Early Settlers and Settlement of Ross County, Ohio. 8vo. 2 50

Fletcher (Wm. B., M.D.) Cholera: its Characteristics, History, Treatment, etc. 8vo. Paper. 1 00

Force (M. F.) Essays: Pre-Historic Man—Darwinism and Deity—The Mound Builders. 8vo. Paper.

Force (M. F.) Some Early Notices of the Indians of Ohio. To What Race did the Mound Builders Belong? 8vo. Paper. 50

Freeman (Ellen). Manual of the French Verb, to accompany every French Course. 16mo. Paper. 25

Gallagher (Wm. D.) Miami Woods, A Golden Wedding, and other Poems. 12mo. 2 00

Grimke (F.) Considerations on the Nature and Tendency of Free Institutions. 8vo. 2 50

Griswold (W.) Kansas: Her Resources and Developments; or, the Kansas Pilot. 8vo. Paper. 50

Hall (James). Legends of the West. Sketches illustrative of the Habits, Occupations, Privations, Adventures, and Sports of the Pioneers of the West. 12mo. 2 00

Hall (James). Romance of Western History; or, Sketches of History, Life, and Manners in the West. 12mo. 2 00

Hanover (M. D.) A Practical Treatise on the Law of Horses, embracing the Law of Bargain, Sale, and Warranty of Horses and other Live Stock; the Rule as to Unsoundness and Vice, and the Responsibility of the Proprietors of Livery, Auction, and Sale Stables, Inn-keepers, Veterinary Surgeons, and Farriers, Carriers, etc. 8vo. 4 00

Hart (J. M.) A Syllabus of Anglo-Saxon Literature. 8vo. Paper. 50

Hassaurek (F.) The Secret of the Andes. A Romance. 12mo. 1 50
The Same, in German. 8vo. Paper, 50c.; cloth. 1 00

Hassaurek (F.) Four Years Among Spanish Americans. Third Edition. 12mo. 1 50

Hatch (Col. W. S.) A Chapter in the History of the War of 1812, in the Northwest, embracing the Surrender of the Northwestern Army and Fort, at Detroit, August 16, 1813, etc. 18mo. 1 25

Hayes (Rutherford B.) The Life, Public Services, and Select Speeches of. Edited by J. Q. Howard. 12mo. Paper, 75c.; Cloth. 1 25

Hazen (Gen. W. B.) Our Barren Lands. The Interior of the United States, West of the One-Hundredth Meridian, and East of the Sierra Nevada. 8vo. Paper. 50

Henshall (Dr. James A.) Book of the Black Bass; comprising its complete Scientific and Life History, together with a Practical Treatise on Angling and Fly Fishing, and a full description of Tools, Tackle, and Implements. Illustrated. 12mo. 3 00

Horton (S. Dana). Silver and Gold, and their Relation to the Problem of Resumption. 8vo. 1 50

Horton (S. Dana). The Monetary Situation. 8vo. Paper. 50

Hough (Franklin B.) Elements of Forestry. Designed to afford Information concerning the Planting and Care of Forest Trees for Ornament and Profit; and giving Suggestions upon the Creation and Care of Woodlands, with the view of securing the greatest benefit for the longest time. Particularly adapted to the wants and conditions of the United States. Illustrated. 12mo. 2 00

Housekeeping in the Blue Grass. A New and Practical Cook Book. By Ladies of the Presbyterian Church, Paris, Ky. 12mo. 13th thousand. 1 50

Hovey (Horace C.) Celebrated American Caverns, especially Mammoth, Wyandot, and Luray; together with Historical, Scientific, and Descriptive Notices of Caves and Grottoes in Other Lands. Maps and Illustrations. 8vo. 2 00

Howe (H.) Historical Collections of Ohio. Containing a Collection of the most Interesting Facts, Traditions, Biographical Sketches, Anecdotes, etc., relating to its Local and General History. 8vo. 6 00

Hunt (W. E.) Historical Collections of Coshocton County, Ohio. 8vo. 3 00

Huston (R. G.) Journey in Honduras, and Jottings by the Way. Inter-Oceanic Railway. 8vo. Paper. 50

Jackson (John D., M.D.) The Black Arts in Medicine, with an Anniversary Address. Edited by Dr. L. S. McMurtry. 12mo. 1 00

Jasper (T.) The Birds of North America. Colored Plates, drawn from Nature, with Descriptive and Scientific Letterpress.

in 40 parts, $1.00 each; or, 2 vols. Royal 4to. Half morocco, $50 00; full morocco, 60 00

The Same. Popular portion only with the Colored Plates. 1 vol. Half morocco, $36.50; full morocco, 40 00

JORDAN (D. M.) Rosemary Leaves. A Collection of Poems. 18mo. 1 50

KELLER (M. J.) Elementary Perspective, explained and applied to Familiar Objects. Illustrated. 12mo. 1 00

KING (John). A Commentary on the Law and True Construction of the Federal Constitution. 8vo. 2 50

KLIPPART (J. H.) The Principles and Practice of Land Drainage. Illustrated. 12mo. 1 75

LAW (J.) Colonial History of Vincennes, Indiana, under the French, British, and American Governments. 12mo. 1 00

LLOYD (J. U.) The Chemistry of Medicines. Illus. 12mo. Cloth, $2 75; Sheep, 3 25

LLOYD (J. U.) Pharmaceutical Preparations; Elixirs, their History, Formulæ, and Methods of Preparation. 12mo, 1 25

LONGLEY (Elias). Eclectic Manual of Phonography. A Complete Guide to the Acquisition of Pitman's Phonetic Shorthand, with or without a Master. A new and carefully revised edition. 12mo. Stiff paper binding, 65c.; Cloth, 75

LONGLEY (Elias). The Reporter's Guide. Designed for Students in any Style of Phonography; in which are formulated for the first time in any work of the kind Rules for the Contraction of Words, Principles of Phrasing, and Methods of Abbreviation. Abundantly illustrated. 12mo. 2 00

LONGLEY (Elias). American Phonographic Dictionary, exhibiting the correct and actual Shorthand Forms for all the useful Words in the English Language, about 50,000 in number, and, in addition, many Foreign Terms; also, for 2,000 Geographical Names, and as many Family, Personal, and Noted Fictitious Names. 12mo. 2 50

LONGLEY (Elias). Every Reporter's Own Shorthand Dictionary. The same as the above, but printed on writing paper, leaving out the Shorthand Forms and giving blank lines opposite each word, for the purpose of enabling writers of any System of Shorthand to put upon record, for convenient reference, the peculiar word-forms they employ. 12mo 2 50

LONGLEY (Elias). Compend of Phonography, presenting a Table of all Alphabetical Combinations, Hooks, Circles, Loops, etc., at one view; also, Complete Lists of Word-signs and Contracted Word-forms, with Rules for Contracting Words for the Use of Writers of all Styles of Phonography. 12mo. Paper. 25

LONGLEY (Elias). The Phonetic Reader and Writer, containing Reading Exercises, with Translations on opposite pages, which form Writing Exercises. 12mo. 25

LONGLEY (Elias). Phonographic Chart. 28 x 42 inches. 50

McBRIDE (J.) Pioneer Biography; Sketches of the Lives of some of the Early Settlers of Butler County, Ohio. 2 vols. 8vo. $6 50. Large paper. Imp. 8vo. 13 00

McLAUGHLIN (M. Louise). China Painting. A Practical Manual for the Use of Amateurs in the Decoration of Hard Porcelain. Sq. 12mo. Boards. 75

McLAUGHLIN (M. Louise). Pottery Decoration: being a Practical Manual of Underglaize Painting. Sq. 12mo. Boards. 1 00

McLAUGHLIN (M. Louise). Suggestions for China Painters. Sq. 12mo. Boards. 1 00

MACLEAN (J. P.) The Mound Builders, and an Investigation into the Archæology of Butler County, Ohio. Illus. 12mo. 1 50

MACLEAN (J. P.) A Manual of the Antiquity of Man. Illustrated. 12mo. 1 00

MACLEAN (J. P.) Mastodon, Mammoth, and Man. Illustrated. 12mo. 60

MACLEAN (J. P.) The Worship of the Reciprocal Principles of Nature among the Ancient Hebrews. 18mo. Paper. 25

MANSFIELD (E. D.) Personal Memories, Social, Political, and Literary. 1803–43. 12mo. 2 00

MANYPENNY (G. W.) Our Indian Wards. A History and Discussion of the Indian Question. 8vo. 3 00

MAY (Col. J.) Journal and Letters of, relative to Two Journeys to the Ohio Country, 1788 and 1779. 8vo. 2 00

METTENHEIMER (H. J.) Safety Book-keeping. Being a Complete Exposition of Book-keeper's Frauds—how Committed, how discovered, how prevented; with other Suggestions of Value to Merchants and Book-keepers in the Management of Accounts. 18mo. Cloth. 1 00

MINOR (T. C., M.D.) Child-bed Fever. Erysipelas and Puerperal Fever, with a Short Account of both Diseases. 8vo. 2 00

MINOR (T. C., M.D.) Scarlatina Statistics of the United States. 8vo. Paper. 50

MORGAN (Appleton). The Shakspearean Myth; or, William Shakespeare and Circumstantial Evidence. 12mo. 2 00

MORGAN (Appleton). Some Shakespearean Commentators. 12mo. Paper. 75

NAME AND ADDRESS BOOK. A Blank Book, with Printed Headings and Alphabetical Marginal Index, for Recording the Names and Addresses of Professional, Commercial, and Family Correspondents. 8vo. 1 00

NASH (Simeon). Crime and the Family. 12mo. 1 25

NERINCKX (Rev. Charles). Life of, with Early Catholic Missions in Kentucky; the Society of Jesus; the Sisterhood of Loretto, etc. By Rev. C. P. Maes. 8vo. 2 50

NICHOLS (G. W.) The Cincinnati Organ; with a Brief Description of the Cincinnati Music Hall. 12mo. Paper. 25

OHIO VALLEY HISTORICAL MISCELLANIES. I. Memorandums of a Tour made by Josiah Espy, in the States of Ohio, and Kentucky, and Indian Territory, in 1805. II. Two Western Campaigns in the War of 1812–13: 1. Expedition of Capt. H. Brush, with Supplies for General Hull. 2. Expedition of Gov. Meigs, for the relief of Fort Meigs. By Samuel Williams. III. The Leatherwood God: an account of the Appearance and Pretensious of J. C. Dylks in Eastern Ohio, in 1828. By R. H. Taneyhill. 1 vol. 8vo. $2 50. Large paper, 5 00

ONCE A YEAR; or, The Doctor's Puzzle. By E. B. S. 16mo. 1 00

OSBORN (H. S.) Ancient Egypt in the Light of Modern Discoveries. Illustrated. 12mo. 1 25

PHISTERER (Captain Frederick). The National Guardsman: on Guard and Kindred Duties. 24mo. Leather. 75

PHYSICIAN'S POCKET CASE RECORD PRESCRIPTION BOOK. 35

PHYSICIAN'S GENERAL LEDGER. Half Russia. 4 00

PIATT (John J.) Penciled Fly-Leaves. A Book of Essays in Town and Country. Sq. 16mo. 1 00

POOLE (W. F.) Anti-Slavery Opinions before 1800. An Essay. 8vo. Paper, 75c.; Cloth, 1 25

PRENTICE (Geo. D.) Poems of, collected and edited, with Biographical Sketch, by John J. Piatt. 12mo. 2 00

QUICK (R. H.) Essays on Educational Reformers. Schools of the Jesuits: Ascham, Montaigne, Ratich, Milton; Comenius; Locke; Rousseau's Emile; Basidow and the Philanthropin, etc. 12mo. 1 50

RANCK (G. W.) History of Lexington, Kentucky. Its Early Annals and Recent Progress, etc. 8vo. 4 00

REEMELIN (C.) The Wine-Maker's Manual. A Plain, Practical Guide to all the Operations for the Manufacture of Still and Sparkling Wines. 12mo. 1 25

REEMELIN (C.) A Treatise on Politics as a Science. 8vo. 1 50

REEMELIN (C.) A Critical Review of American Politics. 8vo. 3 50

REEMELIN (C.) Historical Sketch of Green Township, Hamilton County, Ohio. 8vo. Paper. 1 25

RIVES (E. M. D.) A Chart of the Physiological Arrangement of Cranial Nerves. Printed in large type, on a sheet 28x15 inches. Folded, in cloth case. 50

ROBERT (Karl). Charcoal Drawing without a Master. A Complete Treatise in Landscape Drawing in Charcoal, with Lessons and Studies after Allonge. Translated by E. H. Appleton. Illustrated. 8vo. 1 00

ROY (George). Generalship; or, How I Managed my Husband. A tale. 18mo. Paper, 50c.; Cloth. 1 00

ROY (George). The Art of Pleasing. A Lecture. 12mo. Paper. 25

ROY (George). The Old, Old Story. A Lecture. 12mo. Paper. 25

RUSSELL (A. P.) Thomas Corwin. A Sketch. 16mo. 1 00

RUSSELL (Wm.) Scientific Horseshoeing for the Different Diseases of the Feet. Illustrated. 8vo. 1 00

SATTLER (Eric E.) The History of Tuberculosis from the time of Sylvius to the Present Day. Translated, in part, with additions, from the German of Dr. Arnold Spina, First Assistant in the Laboratory of Professor Stricker, of Vienna: including also Dr. Robert Koch's Experiments, and the more recent Investigations of Dr. Spina on the Subject. 12mo. 1 25

SAYLER (J. A.) American Form Book. A Collection of Legal and Business Forms, embracing Deeds, Mortgages, Leases, Bonds, Wills, Contracts, Bills, of Exchange, Promissory Notes, Checks, Bills, of Sale, Receipts, and other Legal Instruments, prepared in accordance with the Laws of the several States; with Instructions for drawing and executing the same. For Professional and Business Men. 8vo. 2 00

SHEETS (Mary R.) My Three Angels: Faith, Hope, and Love. With full-page illustration. by E. D. Grafton. 4to. Cloth. Gilt. 5 00

SKINNER (J. R.) The Source of Measures. A Key to the Hebrew-Egyptian Mystery in the Source of Measures, etc. 8vo. 5 00

SMITH (Col. James). A Reprint of an Account of the Remarkable Occurrences in his Life and Travels, during his Captivity with the Indians in the years 1755, '56, '57, '58, and '59, etc. 8vo. \$2 50. Large paper. 5 00

STANTON (H.) Jacob Brown and other Poems. 12mo. 1 50

ST. CLAIR PAPERS. A Collection of the Correspondence and other papers of General Arthur St. Clair, Governor of the Northwest Territory. Edited, with a Sketch of his Life and Public Services, by William Henry Smith. 2 vols. 8vo. 6 00

STRAUCH (A.) Spring Grove Cemetery, Cincinnati: its History and Improvements, with Observations on Ancient and Modern Places of Sepulture. The text beautifully printed with ornamental, colored borders, and photographic illustrations. 4to. Cloth. Gilt. 15 00

An 8vo edition, without border and illustrations. 2 00

STUDER (J. H.) Columbus, Ohio: its History, Resources, and Progress, from its Settlement to the Present Time. 12mo. 2 00

TANEYHILL (R. H.) The Leatherwood God: an account of the Appearance and Pretensions of Joseph C. Dylks in Eastern Ohio, in 1826. 12mo. Paper. 30

TEN BROOK (A.) American State Universities. Their Origin and Progress. A History of the Congressional University Land Grants. A particular account of the Rise and Development of the University of Michigan, and Hints toward the future of the American University System. 8vo. 2 00

TILDEN (Louise W.) Karl and Gretchen's Christmas. Illustrated. Square 12mo. 75

TILDEN (Louise W.) Poem, Hymn, and Mission Band Exercises. Written and arranged for the use of Foreign Missionary Societies and Mission Bands. Square 12mo. Paper. 25

TRENT (Capt. Wm.) Journal of, from Logstown to Pickawillany, in 1752. Edited by A. T. Goodman. 8vo. 2 50

TRIPLER (C. S., M. D.) and BLACKMAN (G. C., M. D.) Handbook for the Military Surgeon. 12mo. 1 00

TYLER DAVIDSON FOUNTAIN. History and Description of the Tyler Davidson Fountain, Donated to the City of Cincinnati, by Henry Probasco. 18mo. Paper. 25

VAGO (A. L.) Instructions in the Art of Modeling in Clay. With an Appendix on Modeling in Foliage, etc., for Pottery and Architectural Decorations, by Benn Pitman, of Cincinnati School of Design. Illustrated. Square 12mo. 1 00

VAN HORNE (T. B.) The History of the Army of the Cumberland; its Organization, Campaigns, and Battles. *Library Edition.* 2 vols. With Atlas of 22 maps, compiled by Edward Ruger. 8vo. Cloth, \$8 00; Sheep, \$10 00; Half Morocco, \$12 00. *Popular Edition.* Containing the same Text as the Library Edition, but only one map. 2 vols. 8vo. Cloth. 5 00

VENABLE (W. H.) June on the Miami, and other Poems, Second edition, 18mo. 1 50

VOORHEES (D. W.) Speeches of, embracing his most prominent Forensic, Political, Occasional, and Literary Addresses. Compiled by his son, C. S. Voorhees, with a Biographical Sketch and Portrait. 8vo. 5 00

WALKER (C. M.) History of Athens County, Ohio, and incidentally of the Ohio Land Company, and the First Settlement of the State at Marietta, etc. 8vo. \$6 00 Large Paper. 2 vols. \$12 00. Popular Edition. 4 00

WALTON (G. E.) Hygiene and Education of Infants; or, How to take care of Babies. 24mo. Paper. 25

WARD (Durbin). American Coinage and Currency. An Essay read before the Social Science Congress, at Cincinnati, May 22, 1878. 8vo. Paper. 10

WEBB (F.) and JOHNSTON (M. C.) An Improved Tally-Book for the use of Lumber Dealers. 18mo. 50

WHITTAKER (J. T., M. D.) Physiology; Preliminary Lectures. Illustrated. 12mo. 1 75

WILLIAMS (A. D., M. D.) Diseases of the Ear, including Necessary Anatomy of the Organ. 8vo. 3 50

YOUNG (A.) History of Wayne County, Indiana, from its First Settlement to the Present Time. 8vo. 2 00

LAW TREATISES AND REPORTS.

Adkinson (F.) Township and Town Officer's Guide for the State of Indiana. 12mo. Net. Cloth, $2 00; Sheep. 2 50

Barton (C.) History of a Suit in Equity. Revised and enlarged. 8vo. 2 50

Bates (C.) Ohio Pleadings, Parties, and Forms under the Code. 2 vols. 8vo. Net. 12 00

Bible in the Public Schools. Arguments in favor and against, with Decision of the Cincinnati Superior Court. 8vo. Cloth. 2 00

—— The arguments in faver of, and against. Separate. Paper. Each, 50

Bloom (S. S.) Popular Edition of the Laws of Ohio, in Force June, 1882. Net. Cloth, $3 00; Sheep, 4 00

Bond (L. H.) Reports of Cases Decided in the Circuit and District Courts of the United States for the Southern District of Ohio. 2 vols. 8vo. 14 00

Burns (H.) An Index or Abbreviated Digest of the Supreme Court Reports of the State of Indiana, from 1st Blackford to 77th Indiana, inclusive. 8vo. Net. 5 00

Carlton (A. B.) The Law of Homicide; together with the Celebrated Trial of Judge E. C. Wilkinson, Dr. B. R. Wilkinson, and J. Murdaugh, for the Murder of John Rothwell and A. H. Meeks, including the Indictments, the Evidence, and Speeches of Hon. S. S. Prentiss, Hon. Ben. Hardin, E. J. Bullock, Judge John Rowan, Col. Geo. Robertson, and John B. Thompson, of Counsel, in full. 8vo. Net. 2 50

Cincinnati Superior Court Reporter. 2 vols. 8vo. Net. 10 00
See also Handy, Disney.

Constitution of the United States, with the Fifteen Amendments, Declaration of Independence, etc. 8vo. Paper. 25

Cox (R.) American Trade Mark Cases. A Compilation of all reported Trade Mark cases decided in the United States Courts prior to 1871. 8vo. 8 00

Curwen (M. E.) Manual of Abstracts of Title to Real Property. 12mo. Cloth, $1 50; Sheep, 1 75

Davis (E. A.) New Digest of the Decisions of the Supreme Court of Indiana, to 1875. 2 vols. 8vo. Net. 12 00

Disney's Reports. Cincinnati Superior Court. 2 vols. 8vo. Net. 10 00

Fisher (S. S.) Reports of Patent Cases decided in the Circuit Courts of the United States, 1843–1873. 6 vols. 8vo. Vols. 3 to 6, each. Net. 25 00

Fisher (W. H.) Reports of Patent Cases decided in the Courts of the United States, 1827–1851. 10 00

Fisher (R. A.) Digest of English Patent, Trade Mark, and Copyright Cases. Edited by Henry Hooper. 8vo. 4 00

Fortescue (Sir John). De Laudibus Legum Angliæ. A Treatise in Commendation of the Laws of England. 8vo. Cloth. 3 00

Giauque (F.) The Election Laws of the United States. Being a Compilation of all the Constitutional Provisions and Laws of the United States relating to Elections, the Elective Franchise, to Citizenship, and to the Naturalization of Aliens. With Notes of Decisions affecting the same. 8vo. Paper. 75c.; Cloth. 1 00

Giauque (F.) Ohio Election Laws. 8vo. Paper, $1.00; Cloth, 1 50

Giauque (F.) Manual for Road Supervisors in Ohio. 16mo. Boards. 25

Giauque (F.) Manual for Assignees and Insolvent Debtors in Ohio. Net. Cloth, $2 00; Sheep, 2 50

Giauque (F.) Manual for Guardians in Ohio. Net. Cloth, $2 00; Sheep, 2 50

Giauque (F.) A complete Manual of the Road Laws of Ohio in force 1883, with Forms and Notes of Decisions. *In press.*

Giauque (F.) and McClure (H. B.) Dower and Curtesy Tables, for ascertaining, on the basis of the Carlisle Tables of Mortality, the present value of vested and contingent rights of Dower and Curtesy, and of other Life Estates. 8vo. Net. 5 00

Handy's Reports. Cincinnati Superior Court. 2 vols. in 1. 8vo. Net. 5 00

Hanover (M. D.) A Practical Treatise on the Law relating to Horses. Second edition. 8vo. 4 00

Harris (S. F.) Principles of the Criminal Law. Edited by Hon. M. F. Force. 8vo. Net. 4 00

Indiana Laws. Being Acts and Joint Resolutions of the General Assembly of the State of Indiana, passed at the Regular Session, which was begun and held at Indianapolis, on Thursday, the fourth day of January, 1883, and adjourned without day on Monday, the fifth day of March, 1883. Edited, printed, published, and circulated under authority of law, and with the Secretary of State's authentication. S. R. Downey, Editor. 8vo. 1 00

KENTUCKY REPORTS. Reports of cases decided in the Court of Appeals of Kentucky. 1785-1878. 76 vols. in 61.

KING (J.) A Commentary on the Law and True Construction of the Federal Constition. 8vo. 2 50

McDONALD (D.) Treatise on the Law relating to the Powers and Duties of Justices and Constables in Indiana. Edited by L. O. Schroeder. 8vo. Net 6 00

MATTHEWS (Stanley). A Summary of the Law of Partnership. For use of Business Men. 12mo. Cloth, $1 25; Sheep, 1 50

McLEAN (J.) Reports of Cases decided in the Circuit Court of the United States for the Seventh District. 1829-1555. 6 vols. 8vo. Vols. 2, 4, 5, 6. Each, 6 50

MONTESQUIEU (Baron De). The Spirit of Laws. Translated from the French by Thomas Nugent. New edition, with Memoir. 2 vols. 8vo. Cloth. 6 00

MORGAN (J. A.) An English Version of Legal Maxims, with the Original Forms. Alphabetically arranged, and an Index of Subjects. Second edition. 12mo. Cloth. Net. 2 00

NASH (S.) Pleading and Practice under the Codes of Ohio, New York, Kansas, and Nebraska. Fourth edition, 2 vols. 8vo. Net. 10 00

OHIO AND OHIO STATE REPORTS. Reports of Cases decided in the Supreme Court of Ohio. 1821-1880. 55 vols. Net. 137 50

OHIO STATUTES. Embracing:

Curwen's Statutes at Large, 1833-1860. 4 vols. 8vo. Net. 20 00

Swan & Critchfield's Revised Statutes, 1860. 2 vols. 8vo. Net. 5 00

Sayler's Statutes at Large, 1860-1875. 4 vols. 8vo. 20 00

PECK (H. D.) The Law of Municipal Corporations in the State of Ohio. Second edition. 8vo. 5 00

PECK (H. D.) The Township-Officer's Guide of Ohio. Second edition. Net. Cloth, $2 00; Sheep, 2 50

POLLOCK (F.) Principles of Contract at Law and in Equity. Edited by G. H. Wald. 8vo. Net. 6 00

RAFF (G. W.) Guide to Executors and Administrators in the State of Ohio. Sixth edition. Edited and enlarged by F. Giauque. 12mo. Cloth, $2 00; Sheep, 2 50

RAFF (G. W.) Manual of Pensions, Bounty, and Pay. 1789-1863. 12mo. 2 00

RAFF (G. W.) War Claimant's Guide. Laws relating to Pensions, Bounty, etc. War of 1861-1865. 8vo. 4 00

REINHARD (G. L.) The Criminal Law of the State of Indiana, with Precedents, Forms for Writs, Docket Entries, etc. 8vo. 2 50

SAINT GERMAIN (C.) The Doctor and Student; or, Dialogues between a Doctor of Divinity and a Student in the Laws of England, containing the grounds of those Laws. Revised and corrected. 8vo. Cloth. 3 00

SAUNDERS (T. W.) A Treatise upon the Law of Negligence. With notes of American Cases. 8vo. 2 50

SAYLER (J. R.) American Form Book; a Collection of Legal and Business Forms for Professional and Business Men. 8vo. Cloth. Net. 2 00

STANTON (R. H.) A New Digest of the Kentucky Decisions; embracing all Cases decided by the Appellate Courts, from 1785 to 1877. Second edition. 2 vols. 8vo. Net. 6 00

STANTON (R. H.) A Practical Treatise on the Law relating to Justices of the Peace, etc., in Kentucky. Third edition. 8vo. 7 50

STANTON (R. H.) Manual for the Use of Executors, Administrators, Guardians, etc., in Kentucky. Second edition. 12mo. 1 75

SWAN (J. R.) Pleadings and Precedents. under the Code of Ohio. 8vo. 6 00

SWAN (J. R.) Treatise on the Law relating to the Powers and Duties of Justices of the Peace, etc., in the State of Ohio. Eleventh edition. 8vo. Net. 6 00

SWAN (J. R.) and PLUMB (P. B.) Treatise on the Law relating to the Powers and Duties of Justices, etc., in Kansas. 8vo. 5 00

WALKER (J. B.) and BATES (C.) A new Digest of Ohio Decisions. Second edition. 2 vols. 8vo. Net. 12 00
Vol. 3., 1874-1882. By . Bates. Net. 5 00

WARREN (M.) Criminal Law and Forms. Third edition. 8vo. 5 00

WELLS (J. C.) Treatise on the Separate Property of Married Women, under the recent Enabling Acts. Second edition. 8vo. 6 00

WELLS (J. C.) A Manual of the Laws relating to County Commissioners in the State of Ohio, with carefully prepared Forms, and References to the Decisions of the Supreme Court. Net. 3 50

WILD (E. N.) Journal Entries under the Codes of Civil and Criminal Procedure. With Notes of Decisions. Second edition. 8vo. 4 00

WILCOX (J. A.) The General Railroad Laws of the State of Ohio, in force January, 1874. 8vo. 5 00

WILSON (M. F.) The New Criminal Code of Ohio, with Forms and Precedents, Digest of Decisions, etc. Second edition. 8vo. Net. 5 00

WORKS (John D.) Indiana Practice, Pleadings, and Forms. 2 vols. 8vo. Net 12 00

NASH (Simeon). Lawyer's Case Docket, containing printed Headings, and blank spaces for names of Parties, Memoranda of all the Proceedings, with full printed Instructions, and an Index. Crown size. Half roan, $3.75; Full Sheep. 4 50

LAWYER'S COLLECTION DOCKET. With convenient Ruling, printed Headings, Index, etc. 4to. Half Russia. 3 50

ATTORNEY'S POCKET DOCKET. Ruled and Printed for number of Case, Parties, and kind of Action, Witnesses, etc., with room for 150 cases. Pocket size. Morocco. 1 00

CHANGEABLE POCKET DOCKET. The Docket paper is furnished separately, and so arranged that it may be subsequently bound in one volume. Paper, 50c. per quire. Morocco case, with pocket and band. 2 00

NOTARY'S OFFICIAL REGISTER. Being a Record of Protests and other Official Transactions. 4to. 2 quires. Half sheep, $2 00; 3 quires, half russia. 3 00

COLLECTION RECEIPT BOOK. The Book of Collection Receipts, which is bound in the form of a check book, contains the stub in which is preserved a record of the transaction, and a printed receipt, giving parties, date, interest, indorsers, credits, etc., which is torn off and sent to your correspondent. Book of 50 receipts, 40c.; 100 receipts, 75c.; 200 (two to a page). 1 25

A Catalogue of Legal Blanks will be sent on application.

LAWYER'S OFFICE DOCKET.

The Lawyer's Office Docket. Embracing the History of each Case, and the Proceedings thereon, together with a Digest of the Principles of Law involved, and References to Authorities. With Index and Memoranda. Quarto. 212 pages. Half russia. Cloth sides. Net. 3 50

THE UNITED STATES COMMISSIONER'S DOCKET.

Docket for Commissioners of the United States Circuit Courts, embracing a Full Record of the Proceeding in each Case, with Schedule of Costs, and an Index of Cases. Quarto. Half russia. Net. 3 75
